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A SURVEILLANCE STUDY OF SMOKE FROM HEAVY-DUTY DIESEL-POWERED VEHICLES - SOUTHWESTERN U.S.A.

John O. Storment, et al

Southwest Research Institute

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Office of Air and Water Programs
Office of Mobile Source Air Pollution Control
Certification and Surveillance Division
Ann Arbor, Michigan 48105

January 1974

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FOREWORD

This project was conducted for the U. S. Environmental Protection Agency by the Emissions Research Laboratory of Southwest Research Institute, and was an outgrowth of SwRI Proposal No. 11-7234, dated April 20, 1970, entitled "A Surveillance Study of Smoke from Heavy-Duty Diesel-Powered Vehicles--Southwestern U.S.A." The initial laboratory test phase began in August, 1970, and was completed in June, 1972. The project was subsequently continued for a second year of surveillance activity, and was completed in June 1973.

The EPA Project Officer during this initial period was Mr. Jim Marzen. On August 4, 1972, Mr. John White became Project Officer. The project was under the supervision of John O. Storment, Project Leader and Karl J. Springer, Manager, of the Emissions Research Laboratory, and was known within Southwest Research Institute as Project 11-2861.

ABSTRACT

The primary objective of this study was to determine the effectiveness of the Federal diesel smoke regulations in controlling smoke emissions from a group of heavy-duty diesel engines engaged in routine automotive service. A test fleet consisting of 64 trucks and buses, powered by engines certified to meet 1970 smoke standards, was tested for smoke emissions at four-month intervals over a two-year period. The Federal smoke test was simulated using a chassis dynamometer. Changes in smoke opacity observed during this test period were used to determine, to the extent possible, the effect of time, mileage, and type of service (or duty cycle) on opacity. A secondary project objective was to obtain baseline brake specific emissions data of unburned hydrocarbons, carbon monoxide, and oxides of nitrogen for the vehicles in the test fleet. Beyond determination that the vehicle was capable of safe operation, no alterations were made to the vehicles. Considering the fleet as a whole, smoke opacity tended to increase with time or, equivalently, with mileage. That is, the average opacity of the fleet increased steadily over the baseline opacity at each subsequent inspection.

The rate of smoke increase or deterioration seemed to be more dependent on how the miles were accumulated than on total mileage. Statistical analysis indicated that the "a" and "b" smoke factors from the acceleration and lugdown portions of the Federal test were consistently related to engine make and model. Other important relationships with the smoke factors were found for two and four stroke cycle, naturally aspirated and turbocharged engines. At the end of the first year of testing, before many of the vehicles exceeded the EPA's 100,000 mile definition of useful engine life for Federal smoke, 13 engines, or 20 percent of the fleet, registered smoke opacity in excess of either the "a" or "b" smoke limits for 1970. Twelve of the 13 engines exceeded the Federal limit during the full power lugdown portion of the test. Fifty-nine of the 64 fleet vehicles were tested for gaseous emissions and it was found that 43 engines, or 73 percent of those engines tested, met the 1973 California standards for heavy-duty diesel engines. None of these engines met the 1975 California emissions standards.

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I. INTRODUCTION

This project represents a first attempt to determine how the smoke from a variety of diesel powered vehicles might vary in routine user-type operation.

A. Background

Over the past several years, the Emissions Research Laboratory of Southwest Research Institute has conducted several studies of smoke, odor, and gaseous emissions from diesel-powered trucks and buses. These studies, performed under contracts with the National Air Pollution Control Administration (NAPCA) and the Environmental Protection Agency (EPA), have included a long-range program(1-4)* designed especially to characterize these three facets of diesel emissions. In 1967, during Part II of this long-range study, a special investigation(5) was performed to acquire experience with a preliminary smoke test procedure being considered by the Federal Government as a smoke certification test for new diesel engines. This basic procedure, after several revisions, was adopted and made public in several publications(6,7). Compliance with the Federal smoke standards was required of all heavy-duty diesel engines used in automotive (truck and bus) applications, beginning with engines sold after January 1, 1970.

The Federal smoke test as the test procedure has become known, is described in reference 8, a copy of which is included as Appendix A of this report for ready reference. New regulations governing smoke and gaseous emissions were published(9) for the 1974 model year diesel engine used in trucks and buses over 6000 lbs GVW. The test procedure was eventually unchanged although the limits were lowered, a new "c" factor for peak opacity was added, and a number of refinements made to the procedure.

The Federal test was developed solely as an engine dynamometer procedure, and almost no effort was expended in developing a chassis dynamometer version for either compliance purposes or surveillance tests of in-use vehicles powered by certified-model engines. The Emissions Research Laboratory, using a specially designed tandem-axle chassis dynamometer capable of both power absorption and simulation of vehicle inertia, developed a procedure that closely approximates the engine dynamometer test. The development of the chassis procedure was the technical step required for creation of a surveillance study of smoke output from in-use certified model engines. The justification for such a program was the need for definitive information regarding the smoke characteristics of these certified engines in routine operation in a variety of vehicles and applications.

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*Superscript numbers in parentheses refer to the List of References at the end of this report.

B. Project Objectives

The principal objective of this project was to determine the continued effectiveness of the Federal exhaust smoke regulations on heavy-duty diesel engines engaged in routine automotive operation in the southwestern United States. The effect of time, mileage, and type of operation or service on smoke levels of test vehicles was to be determined. A secondary objective was to acquire baseline data on unburned hydrocarbons (HC), carbon monoxide (CO) and nitric oxide (NO), on a brake specific basis, by the then applicable test procedure.

C. Approach

The approach taken to accomplish these objectives was to first develop a test fleet consisting of 64 vehicles (60 vehicles were required by the contract) powered by the most popular make and model diesel engines. The vehicles were brought to SwRI every four months during a two-year period to perform the chassis dynamometer version of the Federal smoke test. The data from these tests were analyzed to establish the correlation, if any, between changes in opacity and time, mileage, and type of service. Also, at one of the four smoke inspections, each vehicle underwent a brief 13-mode chassis dynamometer emissions test designed to provide a "map" of HC, CO, and NO output on a brake specific basis.

II. THE TEST FLEET

The test fleet was composed of 64 vehicles powered by a variety of diesel engines. Most of these engines were certified under 1970 Federal smoke regulations. A few uncertified 1969 model engines were included in the fleet, but only when it was established that the 1969 engines were in every respect identical to the corresponding 1970 models.

The engine/vehicle combinations in the test fleet were selected for various reasons. First, the engines were, on the whole, among the most popular makes and models currently used in automotive diesel applications in the U. S. However, some engines were included in the fleet because of their reputation for being heavy smoke producers, even though they were not necessarily the most popular engines. The vehicles in the fleet were selected according to their type of service, such as intercity hauling, intracity delivery, and other categories. This breakdown by duty cycle was necessary since a particular make and model diesel engine may power vehicles engaged in several types of service.

The above selection criteria were, of course, tempered by the availability of new or nearly new vehicles of the types desired. At the time (late summer and fall, 1970) that the fleet was developed, a general economic recession was in progress, and sales volume of new trucks and buses was quite low. Hence, considerable difficulty was encountered in obtaining low-mileage vehicles for the test fleet. By mutual agreement with the Project Officer, this difficulty was overcome by changing the desired fleet composition to include other, more obtainable vehicles, and also by accepting vehicles with higher mileage into the fleet. It was originally planned to include only vehicles with less than 10,000 miles, and this goal was fulfilled for the majority of the fleet vehicles. However, some vehicles could not be obtained in this low-mileage condition, and some concessions were necessary on this point.

The composition of the fleet is given in Table 1. The information in Table 1 is summarized in the following outline.

I. Twenty-one (21) vehicles were powered by two-cycle engines.

  A. Fifteen (15) vehicles were in intracity service.
  B. Six (6) vehicles were in intercity service.

II. Forty-three (43) vehicles were powered by four-cycle engines.

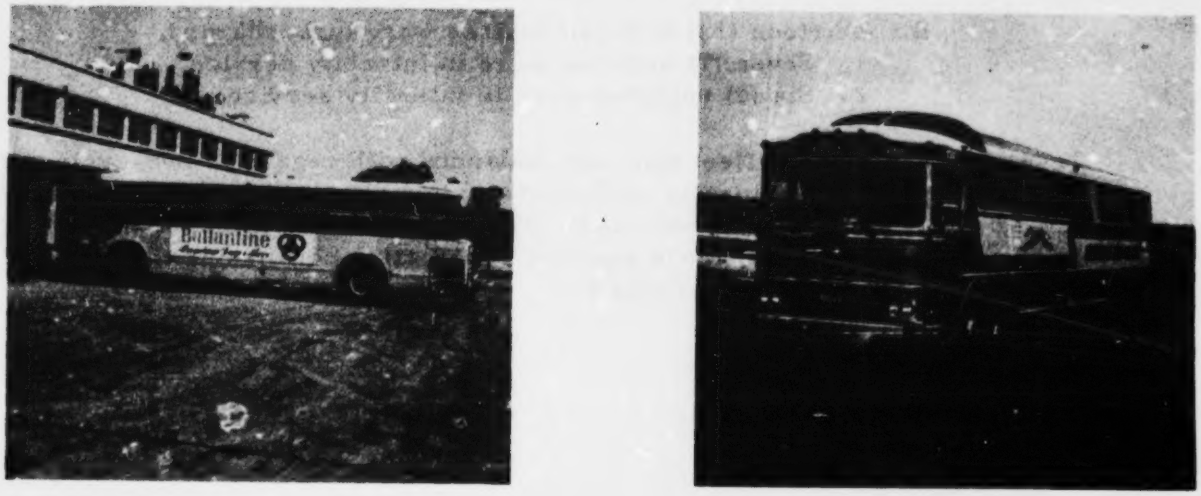
  A. Thirty (30) of these engines were naturally aspirated.
    1. Fifteen (15) vehicles were in intracity service.
    2. Fifteen (15) vehicles were in intercity service.

TABLE 1. VEHICLES IN TEST FLEET

Quantity	Engine/Vehicle Description	Type of Service
10	Detroit 6V-71N/GM Bus	Intracity
5	Detroit 8V-71N/Truck-Tractor	Intercity
1	Detroit 8V-71N/ Bus	Intercity
10	Cummins NHC-250/Truck-Tractor	Intercity
5	Cummins V-903/Truck-Tractor	Intercity
4	Cummins NTC-335/Truck-Tractor	Intercity
5	Mack ENDT 675/Garbage Truck	Intracity
2	Mack ENDT 675/Truck-Tractor	Intercity
2	Mack ENDT 673 B/Truck-Tractor	Intracity
5	Caterpillar 1145/Truck	Intracity
5	Caterpillar 1150/Truck-Tractor	Intracity
4	GM DH-478/Truck-Tractor	Intracity
5	Detroit 6V-53N/Van	Intracity
1	IHC DV 550B/Dump Truck	Intracity
64	Total	

B. Thirteen (13) of these engines were turbocharged.
  1. Seven (7) vehicles were in intracity service.
  2. Six (6) vehicles were in intercity service.

It can be seen that the fleet was well-balanced with regard to two-cycle and four cycle engines, naturally aspirated and turbocharged four-cycle engines, and intracity and intercity vehicles. Some of the test vehicles are shown in Figures 1, 2, and 3. More specific information concerning the engines in the test fleet is given in Table 2.



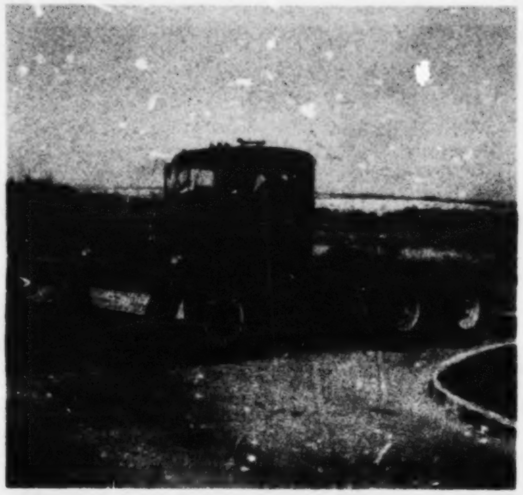
Municipal Bus Powered by General Motors 6V-71N Engine

Intercity Bus Powered by Detroit Diesel 8V-71N Engine

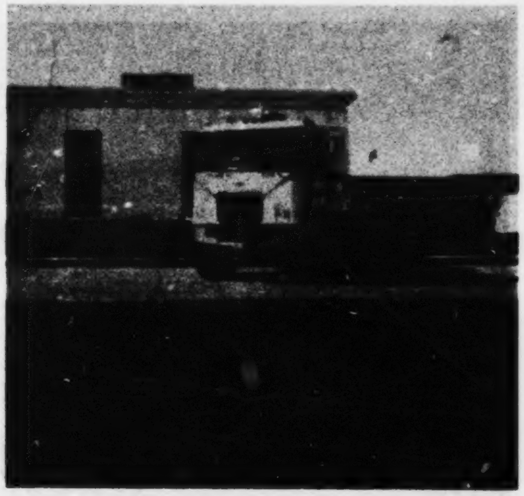
Intercity Truck-Tractor Powered by Detroit Diesel 8V-71N Engine

Intercity Truck-Tractor Powered by Cummins NH-250 Engine

FIGURE 1. TYPICAL VEHICLES FROM SURVEILLANCE TEST FLEET



Intercity Truck-Tractor Powered by Cummins V-903 Engine



Intercity Truck-Tractor Powered by Cummins NTC-335 Engine

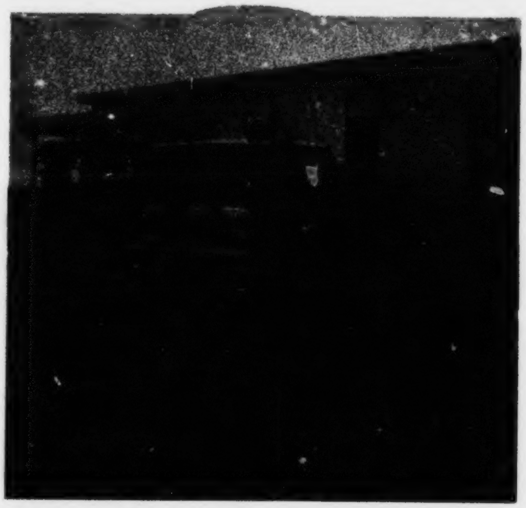
Intercity Truck-Tractor Powered by Mack ENDT 675 Engine

Intracity Truck-Tractor Powered by Mack ENDT 673B Engine

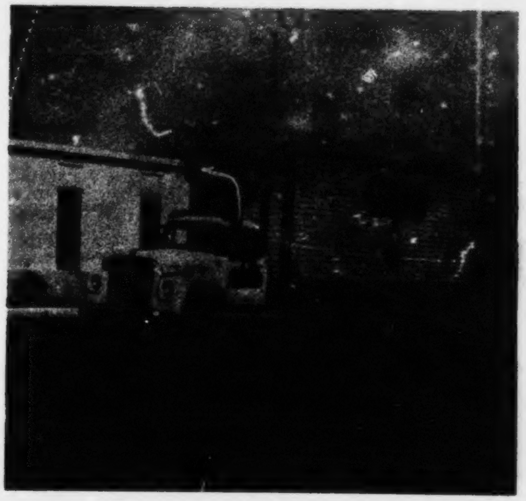
FIGURE 2. TYPICAL VEHICLES FROM SURVEILLANCE TEST FLEET

Intracity Delivery Truck Powered by Caterpillar 1145 Engine

Intracity Truck-Tractor Powered by Caterpillar 1150 Engine



Intracity Truck-Tractor Powered by GM DH-478 Engine



Intracity Delivery Van Powered by Detroit Diesel 6V-53N Engine

FIGURE 3. TYPICAL VEHICLES FROM SURVEILLANCE TEST FLEET

TABLE 2. BASIC ENGINE CONFIGURATIONS IN SURVEILLANCE FLEET

Make and Model(1)	Strokes/ Cycle(2)	Cylinder Arrg't.	Displace. Cu. In.	Comp. Ratio	Type Aspiration	Horsepower at Rated rpm	Torque, lb-ft at rpm	Typical(3) GV or GCW
Detroit Diesel 6V-71N	2	6-V	426	18.7:1	Natural	218 at 2100	604 at 1200	25,000(4)
Detroit Diesel 8V-71N	2	8-V	568	18.7:1	Natural	318 at 2100*	800 at 1600	72,000
Detroit Diesel 6V-53N	2	6-V	318	21:1	Natural	195 at 2600	421 at 1800	41,000
Cummins NHC-250	4	6-I	855	15.3:1	Natural	250 at 2100	658 at 1500	65,000
Cummins V-903	4	8-V	903	17.1:1	Natural	240 at 2400**	707 at 1800	72,000
Cummins NTC-335	4	6-I	855	14.1:1	Turbocharged	335 at 2100***	927 at 1500	72,000
Mack ENDT 675	4	6-I	672	14.9:1	Turbocharged	235 at 2100	890 at 1200	72,000(5)
Mack ENDT 673B	4	6-I	672	14.9:1	Turbocharged	250 at 2100	700 at 1600	65,000
Caterpillar 1145	4	8-V	522	17.5:1	Natural	175 at 3200	353 at 1700	27,000
Caterpillar 1150	4	8-V	573	17.5:1	Natural	200 at 3000	446 at 1400	45,000
GM DH-478	4	6-V	478	17.5:1	Natural	165 at 2800	325 at 2000	44,000
IHC DV 550B	4	8-V	549	16:1	Natural	200 at 3000	372 at 2000	41,000

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(1) All engines feature "open" combustion chamber design except IHC DV 550B which uses the M.A.N. type combustion system.

(2) All 2-stroke/cycle engines use intake air ports while all 4-stroke/cycle engines use valve in head intake air valves.

(3) Typical means that in which engines were engaged in this program. In case of tractors, the gross combined weight (GCW) depends on the type of trailer (semi or double bottom), number and size of tires, and state licensing regulations.

(4) City bus

(5) Varied from 27,000 to 41,000 to 72,000 pounds

* 290 hp with LSN 55 injectors also tested

** 320 hp at 2600 rpm also tested

*** 280 hp version also tested

III. TEST PROCEDURES, INSTRUMENTATION, AND FUELS

The vehicles in the test fleet underwent tests to measure smoke opacity and gaseous emissions of unburned hydrocarbons (HC), carbon monoxide (CO), and nitric oxide (NO). This section of the report describes the test procedures of this surveillance study, as well as the test instrumentation and fuels used.

A. Smoke Test Procedure and Instrumentation

In 1968, the Federal government established standards for smoke output from 1970 and later model diesel engines used in vehicles above 6,000 pounds GVW. Compliance with these standards was (and is) determined by subjecting a typical production engine, representative of a certain class or family of engines, to the Federal smoke compliance test, an engine dynamometer procedure (Appendix A). However, the developmental work for this procedure involved the operation of several diesel-powered truck-tractors on a special chassis dynamometer at SwRI. This work, though revised several times, formed the basis of the Federal smoke compliance test.

The Emissions Research Laboratory successfully developed a chassis-dynamometer version of the Federal smoke test, and previous experiments indicated the two procedures correlate well. The key item in the chassis procedure is a specially-equipped Clayton tandem-axle dynamometer with a power absorption capability of 200 horsepower per axle. Large flywheels attached to one end of the dynamometer rolls provide up to 41,000 pounds of vehicle inertia simulation. Figure 4 shows a bus under test on this dynamometer.

The Federal smoke compliance test, as performed on engine or chassis dynamometer is shown by the schematic drawing on engine speed vs. time in Figure 5. It consists of an initial engine acceleration from 150-250 rpm above the low idle speed to 85-90% of rated engine speed in 5.0 ± 1.5 seconds, a second acceleration from peak torque speed (or 60% of rated speed, whichever is higher) to 95-100% of rated speed in 10.0 ± 2.0 seconds, and (following this second acceleration) a full-power lugdown from 95-100% of rated speed to the particular intermediate engine speed (peak torque speed or 60% of rated speed) in 35.0 ± 5 seconds. The accelerations are made against simulated vehicle inertia furnished by large flywheels connected to the dynamometer rolls or shaft, and/or against a preset load in the power absorption unit. Three of these sequences constitute one smoke test.

The average smoke opacity from the 15 highest-valued one-half second intervals of the two accelerations determine the "a" Factor, and the average opacity from the five highest-valued one-half second intervals of the lugdown mode determines the "b" Factor. The maximum values allowed for "a" and "b" Factors of 1970 through 1973 certification engines are 40- and 20- percent opacity, respectively. For 1974, the "a" Factor was reduced to 20-percent opacity and "b" Factor was reduced to 15- percent opacity. A new peak or "c" Factor, which is the average of the three highest one-half second intervals

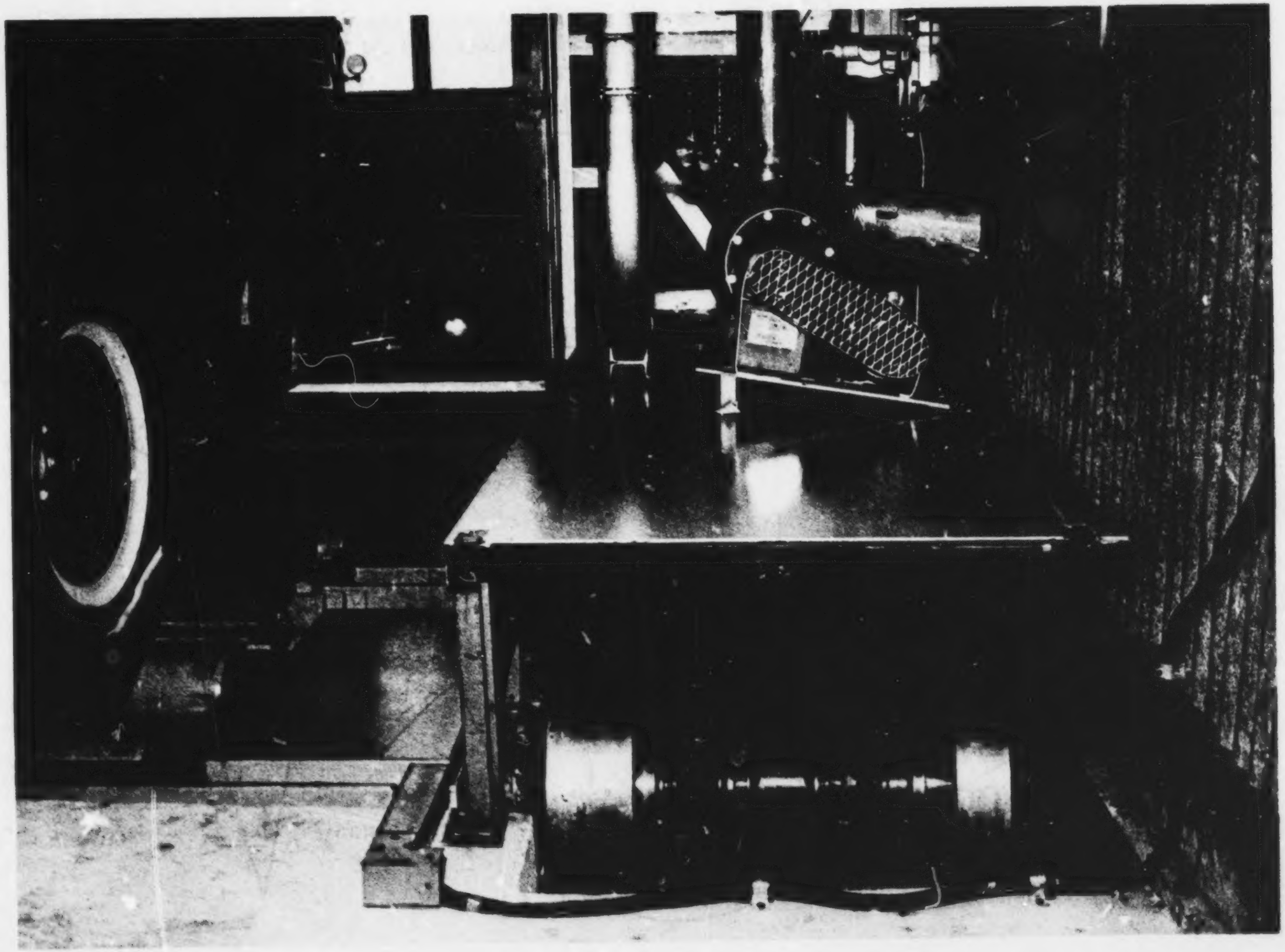

FIGURE 4. CITY BUS UNDER TEST ON SwRI DYNAMOMETER (INERTIA SIMULATION WHEELS IN RIGHT FOREGROUND)

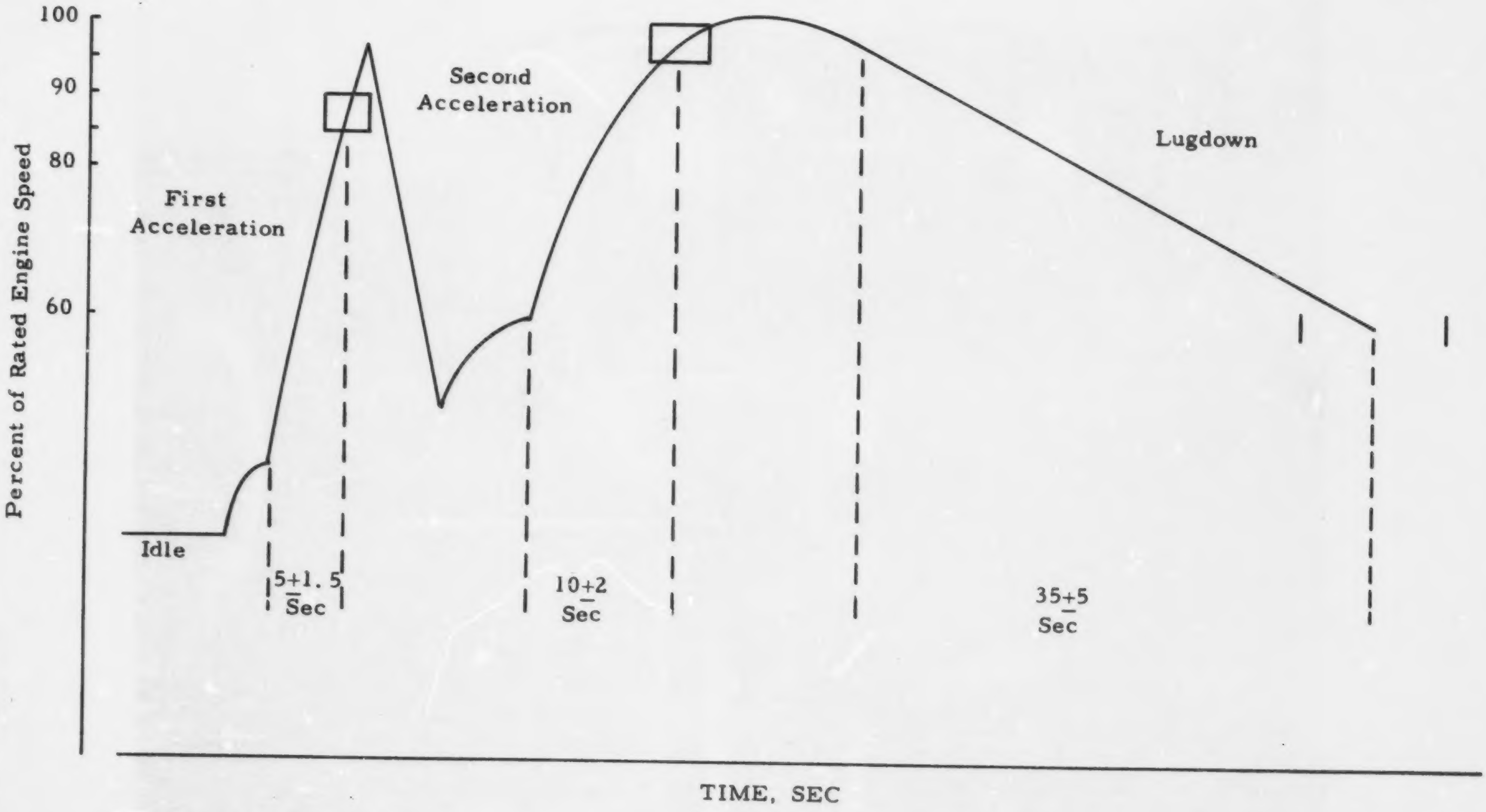

FIGURE 5. SCHEMATIC OF ONE CYCLE OF FEDERAL SMOKE COMPLIANCE TEST - ENGINE SPEED VS TIME

per cycle and is determined from the "a" and "b" chart readings. The three cycle "c" values are then averaged to determine the "c" Factor for the test. For more details on the 1974 test, please see reference 9. All smoke tests were made in accord with the procedures applicable to the 1970-1971 calendar year engines, the then current test procedure. The "c" Factors were computed and reported for possible comparison to 1974 Federal standards.

All vehicles were tested in their "as received" condition, with no adjustments made to the engine. However, a brief pre-test inspection, consisting of a search for anomalies such as crimped or leaking fuel lines, was conducted. Following each smoke test, a power curve (i. e., a series of full-power conditions at various engine speeds) was performed. During this power curve, measurements of rear-wheel horsepower, smoke opacity, and (where possible) inlet restriction, exhaust backpressure, injection system pressure, and turbocharger boost pressure were recorded. These performance parameters were recorded for reference in case the smoke level of any vehicle changed substantially from one test to the next. Thus, it was possible to diagnose the more obvious causes of increased smoke opacity.

The U. S. Public Health Service full-flow, light-obscuration smokemeter (Figure 6) was used to measure exhaust smoke opacity for all tests. The PHS instrument is specified for use in the smoke certification test procedure and is the standard diesel smokemeter used by government and industry.

In the surveillance-type tests conducted for this project, it was not possible to mount the smokemeter directly onto the vehicle exhaust pipe outlet. Hence, a standard method of mounting the smokemeter was developed. First, a piece of steel exhaust pipe approximately three ft long was welded to a piece of flexible exhaust pipe about three or four ft long. The other end of the flex pipe was connected to the vehicle's exhaust outlet, and the smokemeter mounted on the end of the steel exhaust pipe. The diameter of the pipe on which the smokemeter was mounted was determined by the horsepower rating of the engine, per the Federal smoke test procedure. Also, the smokemeter was located on the exhaust pipe so that the distance from the light beam to the end of the pipe was 1. 0 to 1. 5 pipe diameters, again per the Federal procedure.

Figure 7 shows a diesel powered tractor prepared for a chassis version of the Federal Smoke Test Procedure. This tractor was not one of the fleet but is shown to indicate the physical location of the smokemeter read-out remote box and two-pen strip chart recorder (next to technician). Note the location of the smokemeter is above the cab of the truck and is mounted on a short length of flexible pipe followed by a straight section of rigid exhaust tubing of the diameter required for the engine size. In practice, the adapter pipe section was directed either forward or to the rear (usually to the rear).

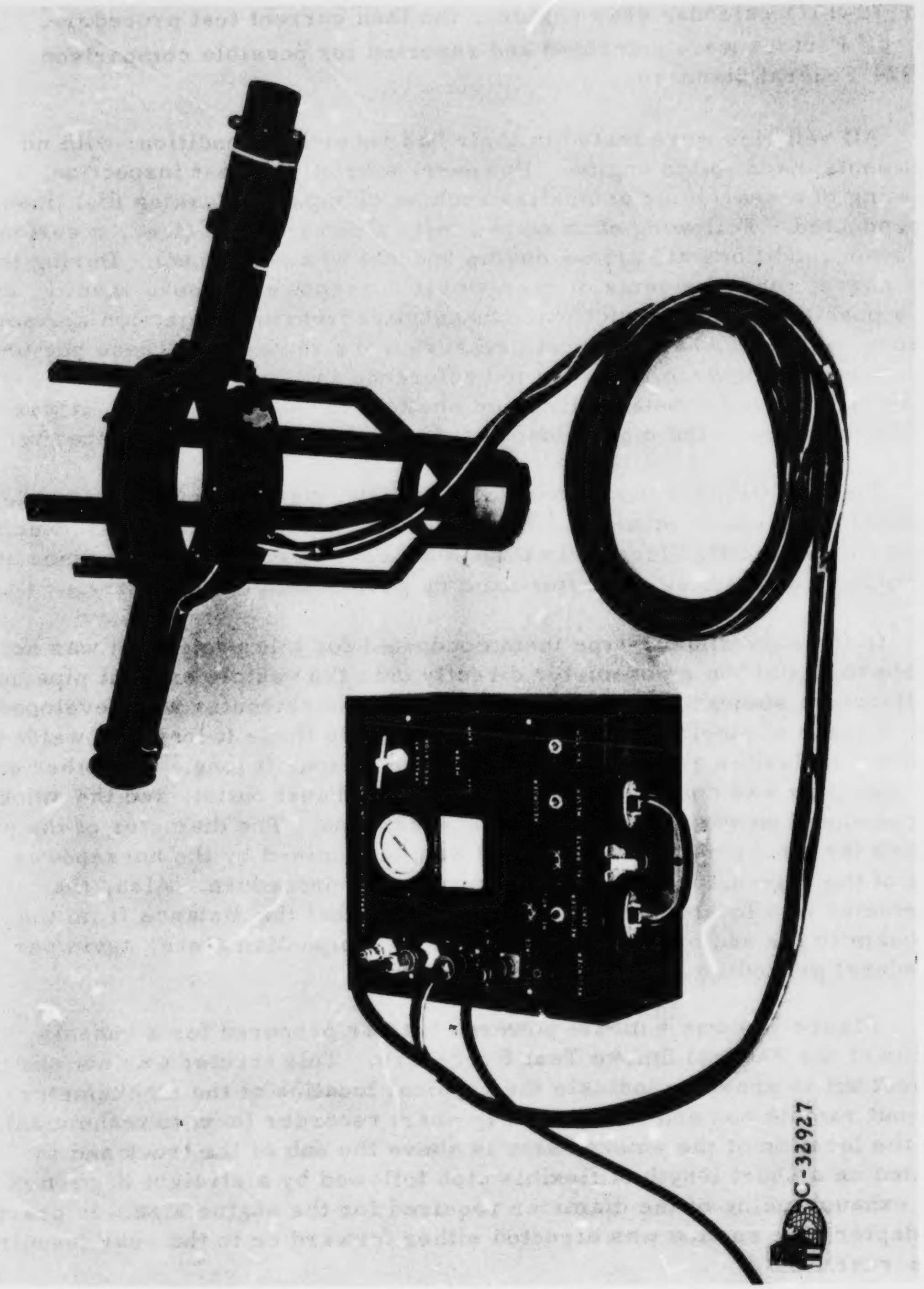

FIGURE 6. PHS FULL-FLOW, LIGHT-EXTINCTION SMOKEMETER

forward or to the rear (usually to the rear).

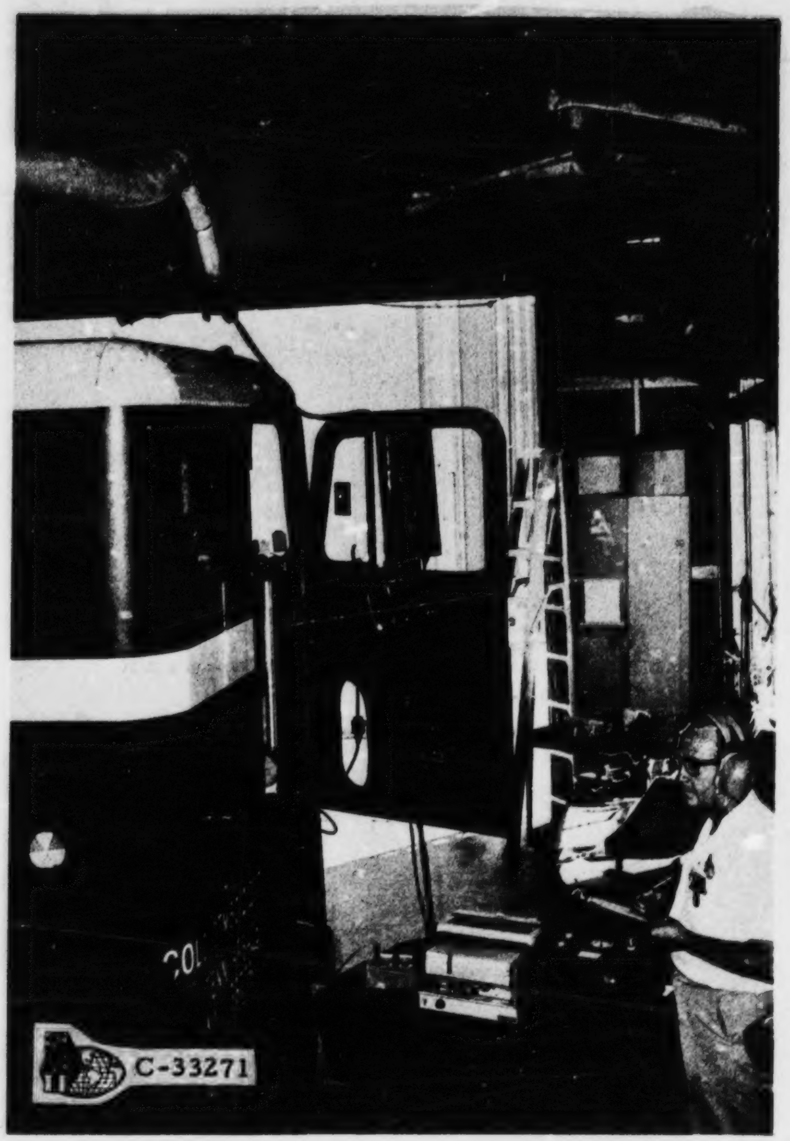

FIGURE 7. TRACTOR PREPARED FOR SMOKE TEST

Figure 8 shows calibration of smokemeter by known opacity neutral density filters and also indicates the location of the smokemeter on the exhaust pipe. Figure 9 shows the interior of the tractor cab. From here, the dynamometer load controls (in driver's hand), electronic counter for engine speed-recorder trace calibration, and other gages and instruments to measure items such as pump delivery pressure (where applicable), inlet and exhaust restrictions and turbocharger boost pressure (where applicable) were monitored.

Two smokemeters were used on vehicles equipped with dual exhaust outlets. For instance, the intercity tractors powered by 8V-71 engines had dual 3.5-inch diameter exhaust stacks. Each stack had its own muffler and served only one bank of the engine. Since the two exhaust systems were separate and independent of each other, it was decided to treat the engine as two separate engines, each with its own exhaust system. The 8V-71 engine is rated 318 horsepower; therefore, each side of its exhaust system was considered to serve a 159-horsepower engine.

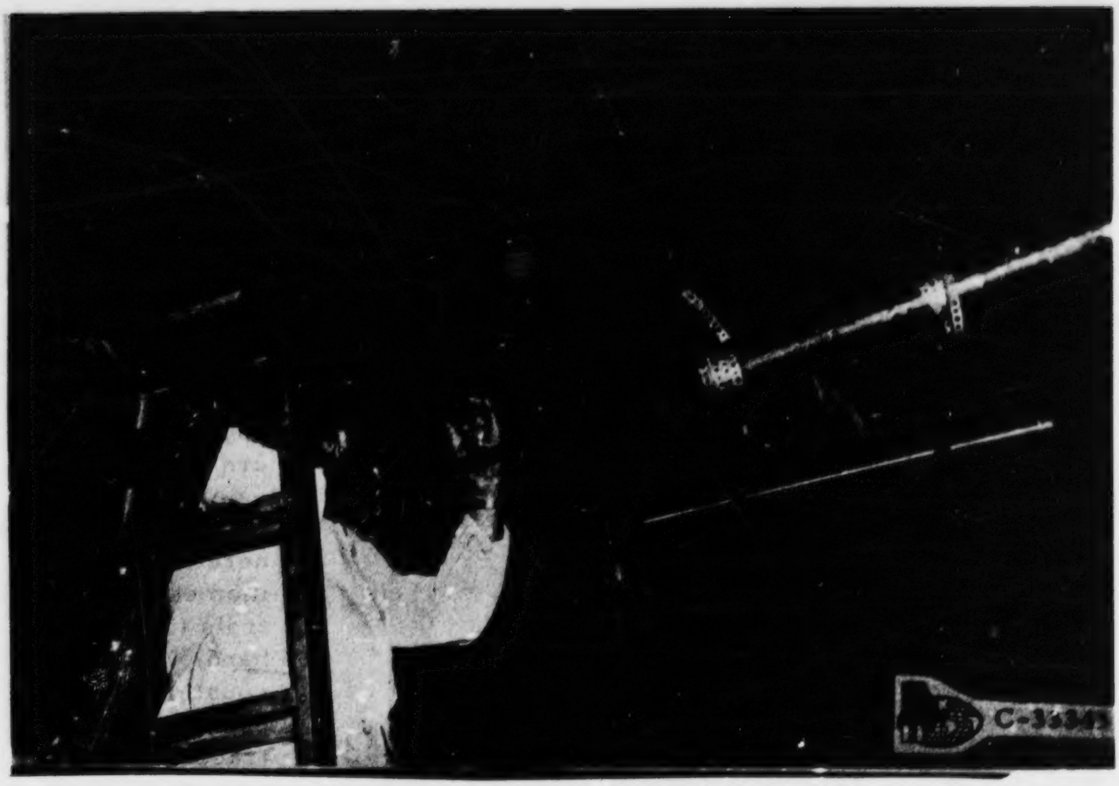

FIGURE 8. PRE-TEST CALIBRATION OF SMOKEMETER WITH NEUTRAL DENSITY FILTERS

FIGURE 9. INTERIOR OF CAB OF TRACTOR UNDER SMOKE TEST

Thus, two smokemeters were used, each mounted on a three-inch diameter pipe adapted to the 3.5-inch exhaust stack.

Smokemeter output and engine speed were recorded on a Texas Instruments dual-pen strip chart recorder with 10-mv range and 0.4 second full-scale response. Recorder chart speed was 12 in per min, which allowed accurate analysis of the opacity traces. Typical smoke opacity and engine speed traces for naturally aspirated and turbocharged diesel engines are shown in Figures 10 and 11, respectively.

Tables 3 and 4 are data sheets on which the chart values for Figures 10 and 11 smoke traces (first sequence only) are recorded for determination of "a" accel, "b" lugdown and "c" peak smoke factors. These two tables are included as examples to indicate the type of data recorded from the strip charts obtained during the over 400 smoke tests performed during the course of this project. The large number of tests and extensive data would make this report too bulky to publish and therefore only the reduced smoke factors are listed for more detailed analysis.

B. Gaseous Emissions Test Procedure and Instrumentation

The California Air Resources Board (ARB) 13-mode, 39 min chassis dynamometer test procedure(10) (Appendix B) was used to obtain gaseous emissions data for the test vehicles. This test procedure was adopted from the procedure developed by the Engine Manufacturers Association (EMA) and its history and salient features are best described in Reference 11.

It should be noted that at the time these tests were performed, there was no Federal Test Procedure applicable to gaseous emissions from heavy duty diesels and the only available procedure was the one developed by EMA and under consideration by the California ARB. A chassis dynamometer alternative, since deleted by California and not included in the Federal Test method, was used for these tests since the engines were in operating trucks and buses. The 1974 Federal Test Procedure(9) for diesel emissions has since included a correction of as-measured CO and NO to a wet basis, since dryers (cold traps and dessicant) are used in the analysis train and a correction for intake air humidity to correct the observed NO to a standard 75 grain per pound of dry air. The test work was completed in 1970 and originally reported in the 1972 interim report on this project without the refinements that have occurred since 1970 when the tests were run.

To convert the hand calculated results from that originally reported, and repeated in this final report without change, requires the programing in of all the data on computer programs now available,

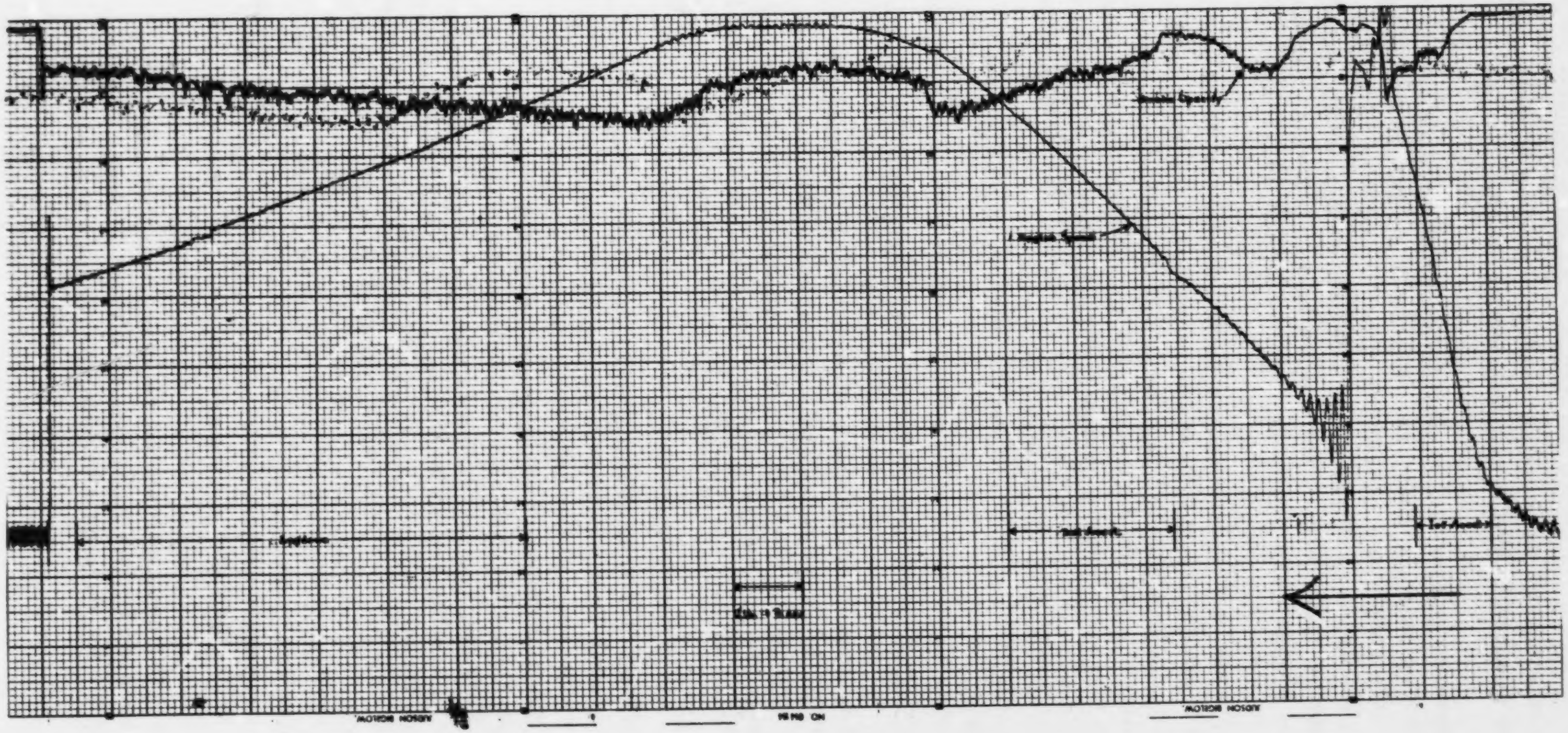

FIGURE 10. SMOKE OPACITY AND ENGINE SPEED TRACES FROM FEDERAL TEST OF NATURALLY ASPIRATED ENGINE

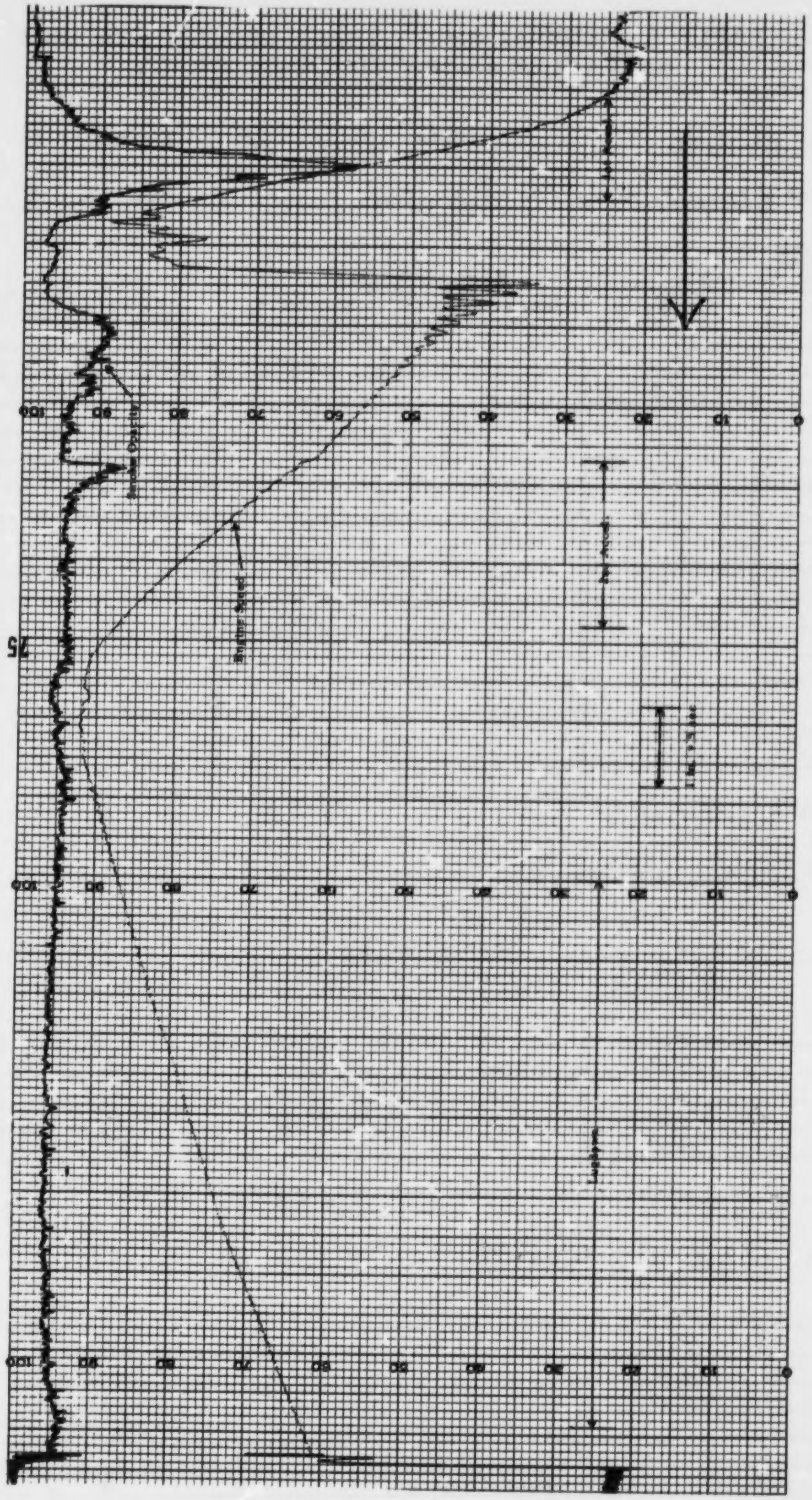

FIGURE 11. SMOKE OPACITY AND ENGINE SPEED TRACES FROM FEDERAL TEST OF TURBOCHARGED ENGINE

TABLE 3. FEDERAL SMOKE TRACE OPACITY READINGS
NATURALLY ASPIRATED DIESEL ENGINE

Vehicle No. Example Date 1-11-73 Evaluated By KH

Model Engine Example- Naturally Aspirated Run No. 1

Accelerations

First Sequence		Second Sequence		Third Sequence	
Interval No.	Smoke %	Interval No.	Smoke %	Interval No.	Smoke %
1	9.0	1	8.5	1	10.0
2	9.0	2	8.7	2	9.5
3	9.0	3	8.5	3	9.5
4	9.0	4	9.0	4	9.0
5	9.2	5	9.5	5	9.5
6	8.8	6	9.3	6	10.0
7	9.5	7	9.0	7	10.3
8	10.0	8	9.5	8	10.5
9	10.5	9	10.0	9	11.0
10	11.2	10	11.0	10	11.0
11	11.0	11	11.5	11	10.7
12	11.0	12	10.5	12	11.3
13	11.2	13	11.0	13	11.0
14	12.0	14	11.5	14	11.5
15	12.2	15	11.8	15	11.5

Total Smoke % 152.6 149.3 156.3

Factor (a) = $\frac{458.2}{45}$ = 10.2 %

Lugging

First Sequence		Second Sequence		Third Sequence	
Interval No.	Smoke %	Interval No.	Smoke %	Interval No.	Smoke %
1	12.8	1	14.0	1	12.0
2	13.0	2	13.5	2	12.0
3	13.0	3	13.0	3	12.5
4	13.0	4	13.0	4	10.5
5	14.0	5	14.0	5	10.5

Total Smoke % 65.8 67.5 57.5

Factor (b) = $\frac{190.8}{15}$ = 12.7 %

Comments:

14.0	14.0	12.5
13.0	14.0	12.0
13.0	13.5	12.0
40.0	41.5	36.5

$\frac{118.0}{9}$ = 13.1 % "c" factor

TABLE 4. FEDERAL SMOKE TRACE OPACITY READINGS
TURBOCHARGED DIESEL ENGINE

Vehicle No. Example   Date 1-11-73   Evaluated By KH

Model Engine Example - Turbocharged   Run No. 1

Accelerations

First Sequence		Second Sequence		Third Sequence	
Interval No.	Smoke %	Interval No.	Smoke %	Interval No.	Smoke %
1	6.3	1	7.0	1	5.5
2	7.5	2	7.3	2	6.3
3	10.5	3	8.5	3	9.0
4	15.5	4	14.0	4	15.4
5	25.0	5	22.0	5	20.0
6	35.5	6	29.0	6	24.0
7	38.5	7	40.0	7	36.3
8	28.0	8	33.0	8	41.0
9	18.5	9	21.3	9	33.5
10	14.0	10	17.0	10	20.5
11	12.0	11	13.0	11	14.0
12	10.0	12	9.5	12	10.5
13	9.0	13	9.0	13	9.3
14	6.7	14	7.0	14	6.2
15	6.5	15	7.3	15	6.0
Total Smoke %	243.5		244.9		257.5

Factor (a) = $\frac{745.9}{45}$ = 16.6%

Lugging

First Sequence		Second Sequence		Third Sequence	
Interval No.	Smoke %	Interval No.	Smoke %	Interval No.	Smoke %
1	5.0	1	7.0	1	5.5
2	6.0	2	6.5	2	6.0
3	5.3	3	6.5	3	5.0
4	6.2	4	6.0	4	5.0
5	6.5	5	6.3	5	5.7
Total Smoke %	29.0		32.3		27.2

Factor (b) = $\frac{88.5}{15}$ = 5.9%

Comments:

	38.5	40.0	41.0
	35.5	33.0	36.3
	28.0	29.0	33.5
	102.0	102.0	110.8

$\frac{314.3}{9}$ = 35.0% "c" factor

as well as entering in the modal barometric pressure, wet/dry bulb temperature readings, and humidities which, because of their lack of specification, were not obtained under all modes. Since the runs were short, 39 minutes, the before and after barometric conditions changed very little and could be used to convert the as measured concentrations to the wet basis (CO and NO) and then convert the observed NO to 75 grains as desired. This additional analysis is beyond the scope of this project, but could be done at a later date by using the modal results listed in Appendix E for each run.

Each vehicle tested for emissions performed two tests in a back-to-back manner. A special 30-min version of the test cycle was used for city buses in order to lessen tire heating problems. Mode times were reduced to two min except for modes 3, 7, 8, and 12, which remained three min long. No difficulty was encountered in stabilizing engine speed and load conditions in the time-shortened modes using fast response SwRI instrumentation systems.

Measurement of unburned hydrocarbons (HC), carbon monoxide (CO), and nitric oxide (NO) were made according to SAE Recommended Practices J215 (HC) and J177 (CO and NO). These Practices are part of the ARB test procedure. The NDIR analyzers for CO and NO are shown in Figure 12, and the high-temperature FIA unit for HC is shown in Figure 13. Note the very short heated sample line for the FIA in this latter figure which was helpful in rapid stabilization of HC read-out.

Engine fuel consumption was measured by means of a mass flowmeter-float tank arrangement manufactured by Flo-Tron, Inc. Temperature of fuel supplied to the engine was maintained in the specified range of 100°F ± 10°F by a heat exchanger in the fuel flow measurement system. Engine air consumption (or exhaust flow) was taken from data furnished by the engine manufacturer for a particular engine model or air flow was directly measured using a calibrated long radius nozzle in accord with SAE Recommended Practice J-244.

C. Test Fuels

All smoke and emissions tests were run on ASTM type DF-1 for city buses and a DF-2 diesel fuel for all others which met the specifications given in the Federal Register, Vol. 33, No. 108, Part II, P. 8320, para. 85.121(b), dated June 4, 1968. The laboratory analysis of typical batches of DF-1 and DF-2 fuel are given in Table 5. The operation of the vehicles during the two-year program was with the usual fuel normally purchased by the fleet operator. These fuels will vary somewhat and generally always have lower sulfur and aromatic content than the Federally specified emissions test fuels.

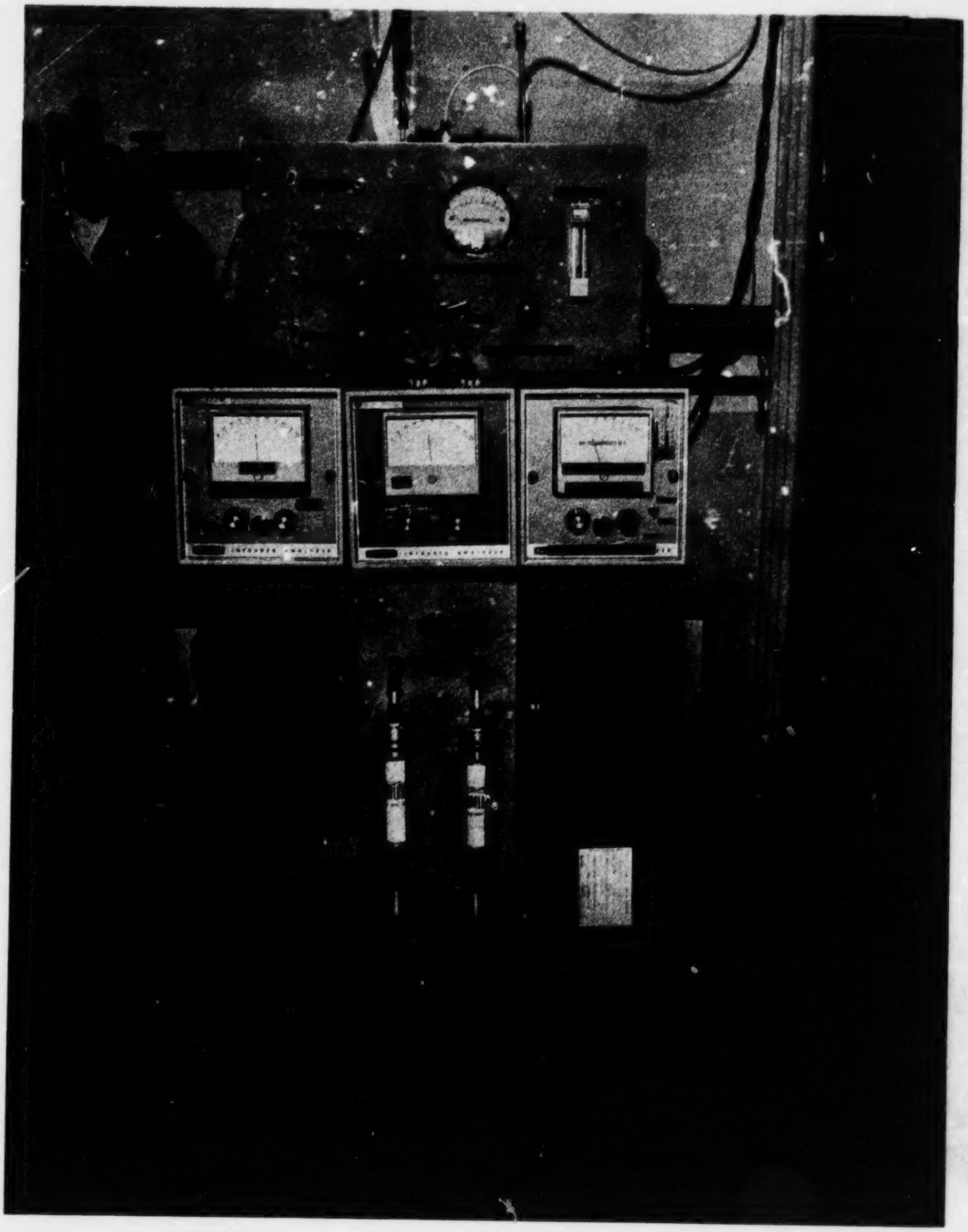

FIGURE 12. INSTRUMENT CART FOR SAMPLING DIESEL EMISSIONS BY NDIR ANALYZERS

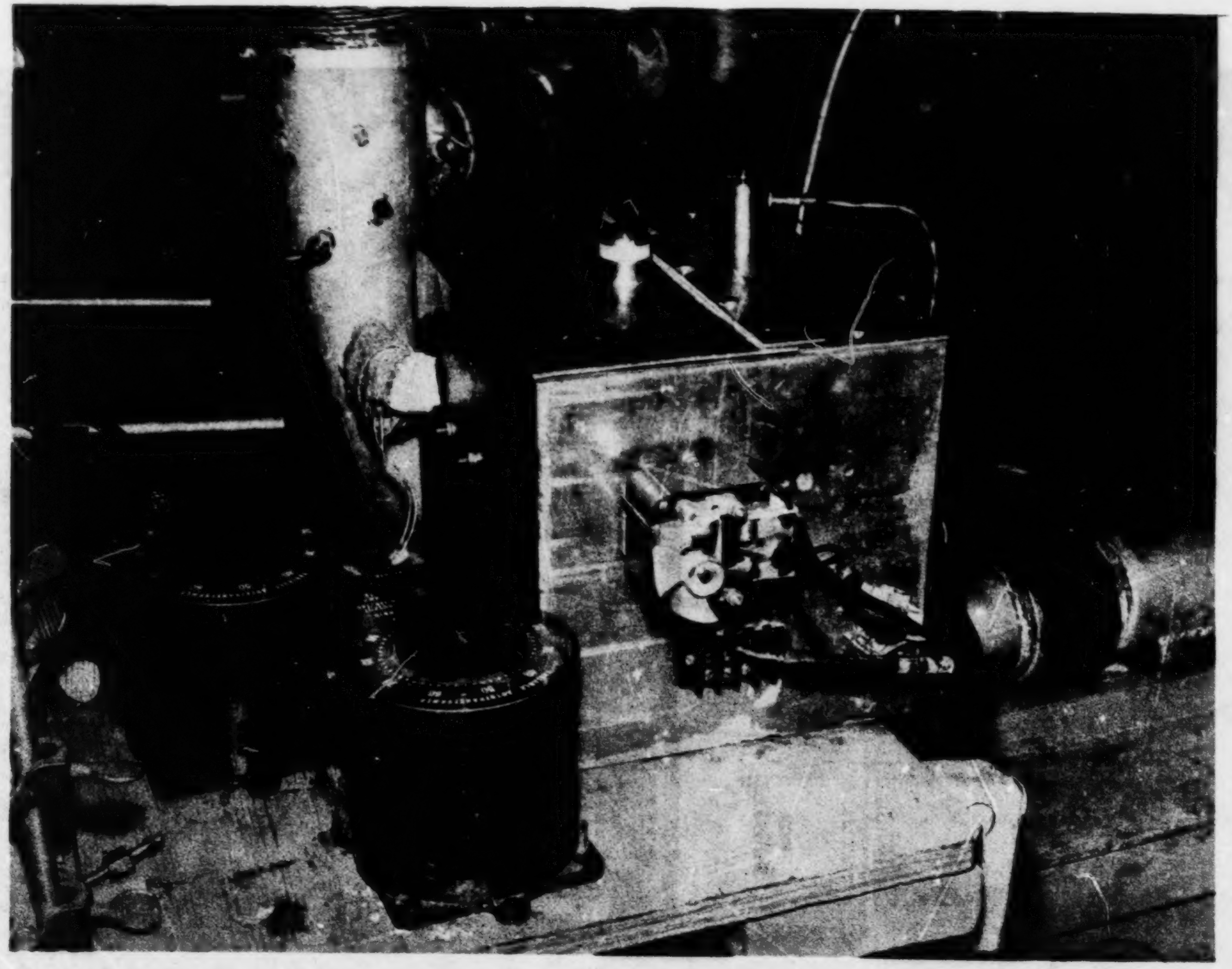

FIGURE 13. SwRI HIGH-TEMPERATURE ANALYZER FOR UNBURNED HYDROCARBONS

TABLE 5. TYPICAL TEST FUELS SPECIFICATIONS

Fuel Type	DF-1	DF-2
Fleet Application	City Buses	All Others
Property		
Cetane	48.0	44.0
Pour Point, ° F	-40	+10
Flash Point, ° F	164	182
Gravity, ° API	42.0	33.8
Viscosity, cent.	1.7	2.6
Hydrocarbon Composition:		
Aromatics, %	14.0	36.7
Total Sulfur, wt. %	0.06	0.30
Distillation, ° F:		
IBP	389	376
10%	406	442
50%	426	522
90%	486	583
EP	547	640

IV. SUMMARY OF SMOKE TEST RESULTS

This section summarizes the results from the two year surveillance test. The test data appear in tabular form in Appendix C for each engine/vehicle group. These groups are as follows: two-cycle engines in intracity service; two-cycle engines in intercity service; four-cycle naturally aspirated engines in intercity service; four-cycle turbocharged engines in intracity service; four-cycle turbocharged engines in intercity service; and midrange two-cycle and four-cycle engines in intracity service.

Some general comments accompany the test results for each of these groups in terms of their average performance, but the reader is, of necessity, relied on to obtain more specific information from the various tables in Appendix C. The Appendix C summary tables list the "a" and "b" smoke factors required by the project and specified for the 1970 calendar year diesel engine in heavy duty truck and bus operation. These tables also contain the "c" factors which will be of interest to the reader in light of the 1974 peak smoke factor. The "c" factor is included as information although it is not applicable to pre 1974 engines. A simple statistical analysis of the data appears in each table, for each engine group. A more extensive analysis is postponed to the next section.

A word concerning some of the terminology used in this and subsequent sections dealing with smoke test results: The term "baseline" refers to the initial or 0-month test of a vehicle. Subsequent tests at 4, 8, 12, 16, 20 and 24 months of operation are referred to as "second round" (or merely "second test"), "third round", and so forth. The term "last test" or "last inspection" always refers to the seventh-round or 24-month test if the vehicle remained in the program for the full two years.

Many of the higher mileage vehicles completed the surveillance period, taken to be 100,000 odometer miles, well before the two year period. Useful life, as defined in paragraph 85.802 of reference 9, means a period of use of 5 years or 100,000 miles of vehicle operation, whichever occurs first. In practice, nearly all the intercity tractors and the intercity bus exceeded 100,000 miles shortly after the 4th round or first year with most intracity units continuing on into the second year of operation.

The procedure was to perform a smoke test inspection throughout the two year period on four month intervals with the final test on high mileage accumulation vehicles made shortly after exceeding the 100,000 odometer mile useful life.

To illustrate the engine groupings and their longevity in this surveillance project, Table 6 is a listing of all vehicles and their odometer readings at each smoke inspection. Of the original 64 trucks and buses, all but three remained in the program. Unit 144 powered by an NTC-335 Cummins engine was lost midway in its test because of transfer of the unit to Dallas, making it no longer available. Two of the garbage trucks, Units 2 and 5, were casualties late in the test program. Unit 2 caught on fire and was destroyed, while Unit 5 was badly wrecked shortly before the final inspection. A few extra vehicles had been included in the fleet at the beginning to try and compensate for such losses. It is fortunate that only three units were lost and then usually late in the program where their loss had minimal effect on the results.

During the test period of mileage shown on Table 6, only one vehicle in the fleet received major engine maintenance. City Bus 817 powered by a Detroit Diesel 6V-71N required a major engine overhaul at 80,000 miles. Several mid-range and a few line-haul type engines received maintenance to the injection system. In a couple of instances this maintenance meant only adjustment while in others a major tune-up was performed. The maintenance performed will be discussed by engine group and its impact on the smoke surveillance assessed. Sometime the maintenance helped and sometimes it did not affect the exhaust smoke.

To the extent that could be verified, each vehicle received the normal maintenance of crankcase lube oil drain, fuel, oil and air filter replacement and the use of recommended parts, fuels and lubricants was used. Some fleets received much better maintenance than others just as the type of service (mileage accumulation and application) varied greatly.

It is not too surprising to the writer to have a diesel engine, especially those used in intercity line-haul type operation, run 100,000 miles without any maintenance to the injection system other than filter replacement. The basic engine is considered to have a nominal 350,000 mile or about 3 years in high mileage operation.

The intracity or mid-range diesel engine is less costly and intended for a less demanding type service and consequently lacks the durability of the line-haul heavy duty engine.

For example, the Cat 175 and 200 and DH478GM engines, considered mid-range, accumulated normally less than 50,000 miles in two years. The 6V-53N Detroit Diesel engine, also considered a mid-range engine, did achieve 100,000 miles in the two year period.

The useful life definition of the Federal Register was adopted for purposes of certification testing and does not necessarily reflect the useful life of the diesel engine. For engines built for intercity, heavy duty

TABLE 6. SMOKE SURVEILLANCE TEST FLEET ODOMETER READINGS (MILES)

Vehicle No.	Engine Make and Model	Smoke Inspection Interval (Test Round)						
		1(0mo)	2(4mo)	3(8mo)	4(12mo)	5(16mo)	6(20mo)	7(24mo)
815	Detroit	44,059	66,203	88,853	104,879	123,623		
816	Diesel	32,427	54,560	77,659	100,497	116,232		
817	6V-71N	45,575	66,548	91,264	109,848	124,077		
818		49,190	71,200	93,751	109,863	129,348		
819		46,277	72,542	93,324	110,075	129,680		
820		43,499	65,590	92,874	108,609	123,559		
821		41,982	68,137	92,566	108,480	127,499		
822		42,041	69,155	92,935	104,970	122,074		
823		43,765	69,855	93,334	109,619	124,042		
824		41,479	67,223	92,288	99,723	123,180		
405	Detroit	8,480	59,990	95,319	132,550			
104	Diesel	5,941	62,856	115,686	176,364			
105	8V-71N	5,165	61,485	94,788	144,404			
106		6,958	48,487	72,198	129,955			
107		12,393	61,050	89,642	137,221			
V-591		12,894	52,441	92,000	127,460			
H-3	Detroit	3,992	22,754	44,144	60,161	79,044	88,400	104,688
H-4	Diesel	5,201	20,402	36,413	52,767	79,568	99,525	110,346
H-8	6V-53N	2,963	26,664	40,252	57,444	90,775	110,421	
H-10		3,111	23,926	39,544	57,835	79,742	91,677	107,346
H-16		339	21,053	34,806	46,513	74,041	90,310	103,316
21	Cummins	31,901	50,738	77,486	108,832			
22	NH-250	34,842	71,829	93,108	107,568			
62		32,100	74,204	97,821	161,645			
15743		54,318	76,652	87,434	104,719			
15744		56,622	77,254	84,166	106,967			
15745		58,001	76,711	112,844	120,839			
15746		40,850	61,766	101,749	122,422			
24658K		12,123	19,168	46,886	81,574	113,321		
26353K		239	37,369	55,715	86,822	122,420		
26354K		268	39,787	59,161	90,000	128,771		

TABLE 6 (Cont'd). SMOKE SURVEILLANCE TEST FLEET ODOMETER READINGS (MILES)

Vehicle No.	Engine Make and Model	Smoke Inspection Interval (Test Round) 1(0mo)	2(4mo)	3(8mo)	4(12mo)	5(16mo)	6(20mo)	7(24mo)
966	Cummins	813	41,027	82,648	122,180			
968	V-903	14,709	47,073	116,787	140,829			
970		11,782	43,386	77,223	116,452			
972		13,589	40,833	72,578	112,126			
415		12,366	75,515	136,249	162,248			
20	Cummins	18,665	65,013	106,934	128,663			
144	NTC-335	31,766	87,491	*				
458		87,407	126,772	173,104	219,279			
6213		81,519	114,382	155,570	177,745			
1	Mack	67,339	109,851	151,350	205,110			
2	ENDT 675	1,454	14,062	27,041	42,967	**		
3		28,574	40,754	54,826	71,432	84,158	95,066	100,435
4		1,505	4,636	18,576	32,352	46,571	65,212	74,637
5		5,045	11,402	27,779	35,057	50,928	62,928	***
5		70,328	113,283	153,169	194,783			
6		1,510	11,256	25,566	45,566	58,961	76,395	85,990
060122	Mack	6,306	10,490	13,412	17,041	22,050	27,575	33,852
060124	ENDT 673B	4,838	8,986	12,896	16,813	22,176	24,813	31,703
507	Cat	4,493	7,222	11,096	14,401	17,766	21,930	27,437
510	175	3,950	6,222	8,669	11,058	13,887	17,161	22,458
512	(1145)	2,387	3,438	5,328	7,298	9,818	12,343	16,981
519		5,831	17,033	26,619	31,569	41,223	54,168	67,497
527		2,022	4,006	5,968	7,955	10,887	14,315	20,771

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* Deleted from test fleet as truck sold and transferred to Dallas

** Deleted from test fleet due to fire that destroyed truck

*** Wrecked and engine ruined as a result

TABLE 6 (Cont'd). SMOKE SURVEILLANCE TEST FLEET ODOMETER READINGS (MILES)

Vehicle No.	Engine Make and Model	Smoke Inspection Interval (Test Round)						
		1(0mo)	2(4mo)	3(8mo)	4(12mo)	5(16mo)	6(20mo)	7(24mo)
880	Cat	13,149	16,156	19,481	22,364	25,819	28,741	33,278
881	200	8,226	11,781	14,795	17,844	21,241	23,947	28,144
883	(1150)	7,721	10,800	13,600	16,912	20,286	23,333	27,443
884		7,650	21,645	24,701	26,962	29,996	33,130	37,346
885		8,871	12,752	15,401	18,540	22,087	24,881	29,503
118	GM	5,285	8,578	11,607	14,893	18,402	21,958	28,184
133	DH 478	7,134	10,602	14,867	18,053	23,740	33,909	43,105
137		762	2,844	5,237	7,764	10,568	14,775	23,077
190		970	3,200	5,936	8,634	10,443	15,839	22,847
631	DV-550 B IHC	10,029	17,655	23,925	30,580	37,778	44,979	49,408

operation, the time to injector maintenance is generally on the order of 100,000 to 125,000 miles. Perhaps this was the intent of the Register, to place useful life to first serious repair of the injector system where injectors are removed for cleaning, the pump is adjusted or maintained and valves adjusted. Most heavy duty line-haul (6 and 8V-71 Detroit Diesel, Cummins NHC-250, NTC-335 and V-903, and Mack Endt-675) reached the point of first major tune-up, consisting of removal of injectors, etc. Of the mid-range category only the 6V-53 Detroit Diesel engines reached the point of major tune-up. For purposes of discussion, this summary of smoke test results will be presented first on a time base, i.e., by inspection period and then by odometer miles. Results of these smoke tests, the Federal "a", "b" and "c" Factors, are often referred to collectively as "smoke factors".

A. Smoke Results by Inspection Period

This subsection summarizes the entire two year surveillance smoke results obtained at four month inspection intervals. Each major engine/vehicle group will be discussed separately using bar charts of the group average "a" and "b" factors.

1. Detroit Diesel 6V-71N Engines in Intracity Buses

The average "a" and "b" factors for the ten city buses powered by Detroit Diesel 6V-71N engines with 60 LSN injectors and fueled with DF-1 are shown in the bar chart, Figure 14, for five inspections (0, 4, 8, 12 and 16 months). These engines were characterized by their low smoke opacity throughout the two-year test period. To place the overall 6.0 percent "a" and "b" readings in perspective, the limit of visibility of diesel engine smoke from buses and trucks is generally 3 to 4 percent opacity by the US PHS (EPA) full flow light obscuration type smokemeter.

These light smoke levels, just above the visibility limit but barely so, are not only impressive in their minimal level, but also their behavior with time was quite encouraging. One reason for the very low smoke from the city buses was the fuel. DF-1, a kerosene type diesel, is lighter than DF-2 and when used with volume metering fuel injectors results in a derating of the power output of the engine. Although less power is available, since less mass of fuel is being burned, many bus operators prefer this more expensive fuel because of its lower smoke and less objectionable odor quality.

The highest "a" and "b" Factors at the initial test were approximately 10- and 8.5 - percent opacity, respectively. The initial mileages for these vehicles ranged from 32,400 to 49,200 miles. Only slight changes from the baseline "a" and "b" Factors were observed at

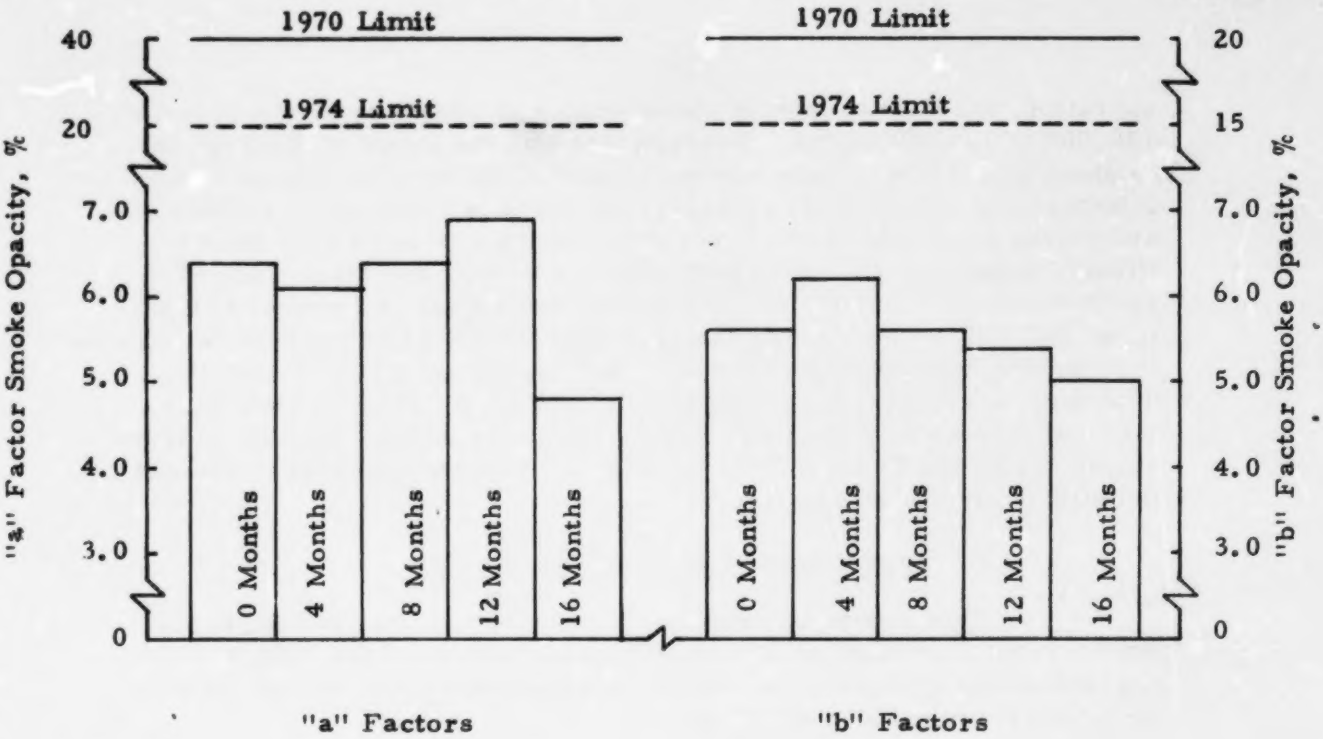


FIGURE 14. AVERAGE "a" and "b" FACTORS
TEN DETROIT DIESEL 6V-71N ENGINES

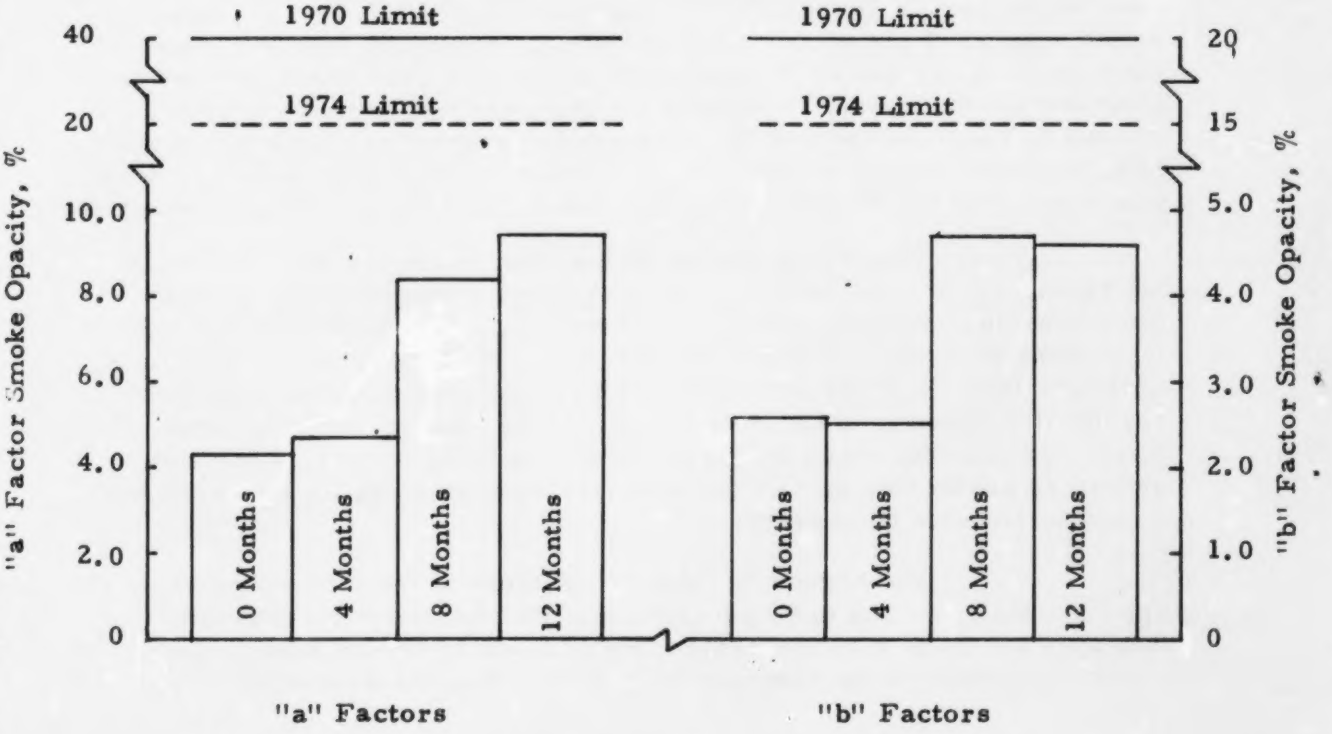


FIGURE 15. AVERAGE "a" AND "b" FACTORS
SIX DETROIT DIESEL 8V-71N ENGINES

the second- and third-round tests. Note that the average smoke factors at these tests differed little, if any, from those of the initial test per Appendix Table C-1.

There also was little change between the initial and last (16-month) sets of data, with one exception, which will be noted presently. The highest fourth-round "a" and "b" Factors were about 9- and 7-percent opacity, respectively. Five engines had increased "a" and "b" Factors over baseline, and five engines showed decreased smoke factors. The average fourth-round "a" and "b" Factors were very close to those of the first test. All of the vehicles were continued to 16 months of operation with unit 824 exhibiting relatively high smoke of 11 percent "a" and 11.7 percent "b".

The only engine in this group that had a large and abrupt change in smoke opacity during the test period was in Bus No. 817. Shortly after the third-round test, this engine received a major overhaul consisting of new rings, cylinder liners, camshafts, injectors, and a valve job. The bus was returned to the Emissions Research Laboratory after a short break-in period, and another smoke test and power curve were performed. The "a" and "b" Factors were approximately 1.5- and 1.0-percent opacity, respectively. Rear wheel power was about the same as when the bus was first tested at 35,500 miles. Engine failure was quite sudden, and for this reason the third-round tests results were thought to represent the smoke prior to any substantial engine deterioration. Hence, these data are included with the other third-round results. Incidentally, this was the only engine in this group to undergo extensive maintenance; the others had only routine service performed on them.

The data from the five inspections have been statistically analyzed to obtain not only mean values, but also the quantities associated with the dispersion or variation of the data about these mean values, namely, the mean deviation, standard deviation, and the coefficient of variation. The standard deviation gives the absolute variation of the data, while the coefficient of variation expresses the standard deviation as a percentage of the mean and hence is a relative measure of variation. For example, the mean (average) values of the first-round "a" and "b" Factors are similar (6.4- and 5.6-percent opacity, respectively) and their standard deviations are the same (1.8). However, the "b" Factors have a larger coefficient of variation and therefore have a higher degree of relative dispersion.

It should be noted on Table C-1 that the fourth-round smoke factors for Bus No. 817 were not included in the statistical analysis. This omission was justified since the recently overhauled engine had very low smoke factors that artificially lowered the mean values and increased the variability of the data. Also, the failure of a heavy-duty diesel engine after only 80,000 miles of operation is certainly an uncommon event. Hence, it was thought that the surveillance nature of the project would best be served if the test results for this vehicle were reported, but with no statistical significance attached to them.

In general, the variation of the data was consistent and rather large through the first three inspections, then dropped sharply at the fourth test. Therefore, at least for the fourth inspection, the data showed a greater tendency to converge to a central value. The "a" Factors generally showed the largest absolute variation at each of the five tests, while the "b" Factors had the greatest relative variation.

2. Detroit Diesel 8V-71N Engines in Intercity Service

The "a" and "b" Factors for these engines are presented in Appendix Table C-2 and their averages shown in Figure 15. Five engines powered truck-tractors in line-haul service, and one engine was in an intercity bus. The truck-tractors were equipped with dual exhaust stacks, and, as previously mentioned, smoke opacity was measured separately and simultaneously for each stack. The smoke factors generated by the left and right engine banks are hence presented separately in Table C-2 and demonstrate that the two banks of an engine often produced smoke of different opacity.

The Figure 15 bar chart of average "a" and "b" factors indicate both were doubled between the 4 and 8 month inspections. The "a" changed from about 5 to 10 percent opacity while the "b" factor increased to 4.5 from 2.5 percent opacity. Although these smoke levels are, like the city bus, termed "light" the trend to higher smoke sometime after the 4th inspection is of interest.

These engines, like the 6V-71 bus engines, had low smoke factors at all four of the tests. The first-round "a" Factors ranged from 1.5- to 7.3-percent opacity, while the corresponding "b" Factors ranged from 1.0- to 5.4-percent opacity. Vehicle mileages at this initial test were low, from about 5,200 to 12,900 miles. At the second inspection, there were an equal number of engines with increased and decreased smoke opacity from the baseline values. Note that the average "a" and "b" Factors were nearly identical at the first- and second-round tests. By the third inspection, all but one engine had higher smoke opacity than at the initial test, and the average "a" and "b" Factors were approximately twice the values of the baseline averages.

The fourth-round smoke factors were, however, quite low, especially in view of the very high mileage accumulated by these vehicles.

The "a" Factors, listed on Table C-2, ranged from 4.8- to 14.1-percent opacity, and their average was 9.5-percent opacity. The "b" Factors went from 2.0- to 10.9-percent opacity, with an average of 4.6-percent opacity. Elapsed test mileage for the one-year period was 114,000 to 170,000 miles, and total vehicle mileage at the last test was 127,000 to 176,000 miles. None of the engines underwent any maintenance that could have greatly affected the smoke opacity (e.g., maintenance of the injection system or internal parts of the engine).

The data from the four inspections of these vehicles were statistically analyzed in the same manner as the data for the city buses. However, for statistical purposes, the test results for the left and right engine banks of the five truck-tractors were considered as discrete and independent results. In other words, the statistical analysis considers the results as arising from tests of ten four-cylinder, single exhaust engines. This approach is justified by the fact that no satisfactory method of combining smoke opacities from two sources (stacks) exists, as it does for the brake specific mass-flow emissions data of the emissions tests.

The variation of the data was rather large, as can be seen from the standard deviations and coefficients of variation in Table C-2. The "a" Factors consistently showed the most absolute variation, while the "b" Factors had the higher relative variation. The degree of absolute variation for both smoke factors increased at the second and third inspections, then decreased between the third and fourth tests. The relative variation for both factors increased at the second test, then decreased at the third and again at the fourth test. In general, these are similar to the trends in data variation for the 6V-71 bus engines. However, the 8V-71 engines had more relative and absolute data variation than the 6V-71 engines.

3. Detroit Diesel 6V-53N Engines in Intracity Trucks

Figure 16, the average results for this group of five delivery trucks showed at their initial test, that these engines generally had the low smoke factors of the other two-cycle engines in the project. This Figure was prepared from smoke factors by truck for each inspection shown in Appendix Table C-3. First round "a" Factors were 5.1- to 15.2-percent opacity (this latter value was far above the others) and "b" Factors ranged from 1.3- to 7.6- percent opacity. The average "a" and "b" values were 9.1 and 3.5, respectively. Initial vehicle mileage was 300 to 5,200 miles. Surprising opacity changes were noted at the second-round inspection of these engines. Four engines had very large increases over their baseline opacities, while the engine (in Truck No. 4) that had high smoke at the first test showed greatly reduced opacity at the second test. This reduction was due to an adjustment of injector and valve settings, performed in response

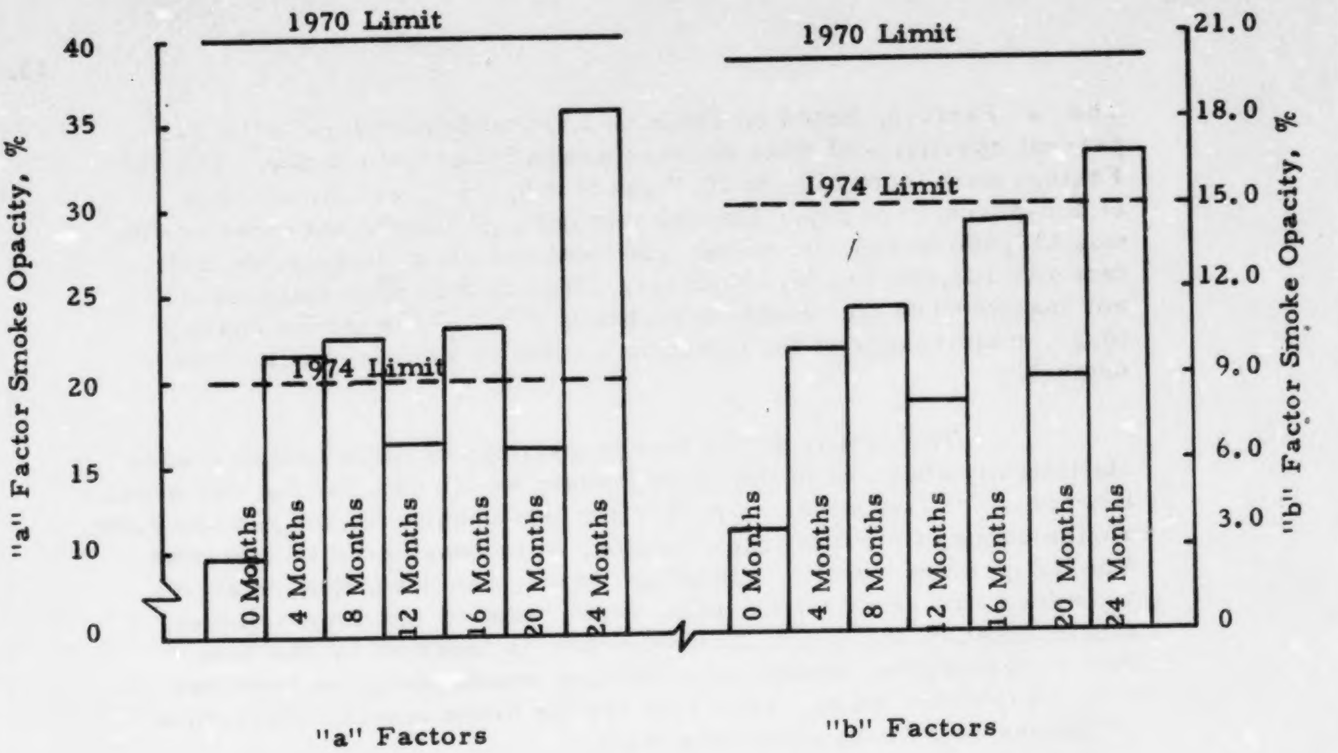


FIGURE 16. AVERAGE "a" and "b" FACTORS
FIVE DETROIT DIESEL 6V-53N ENGINES

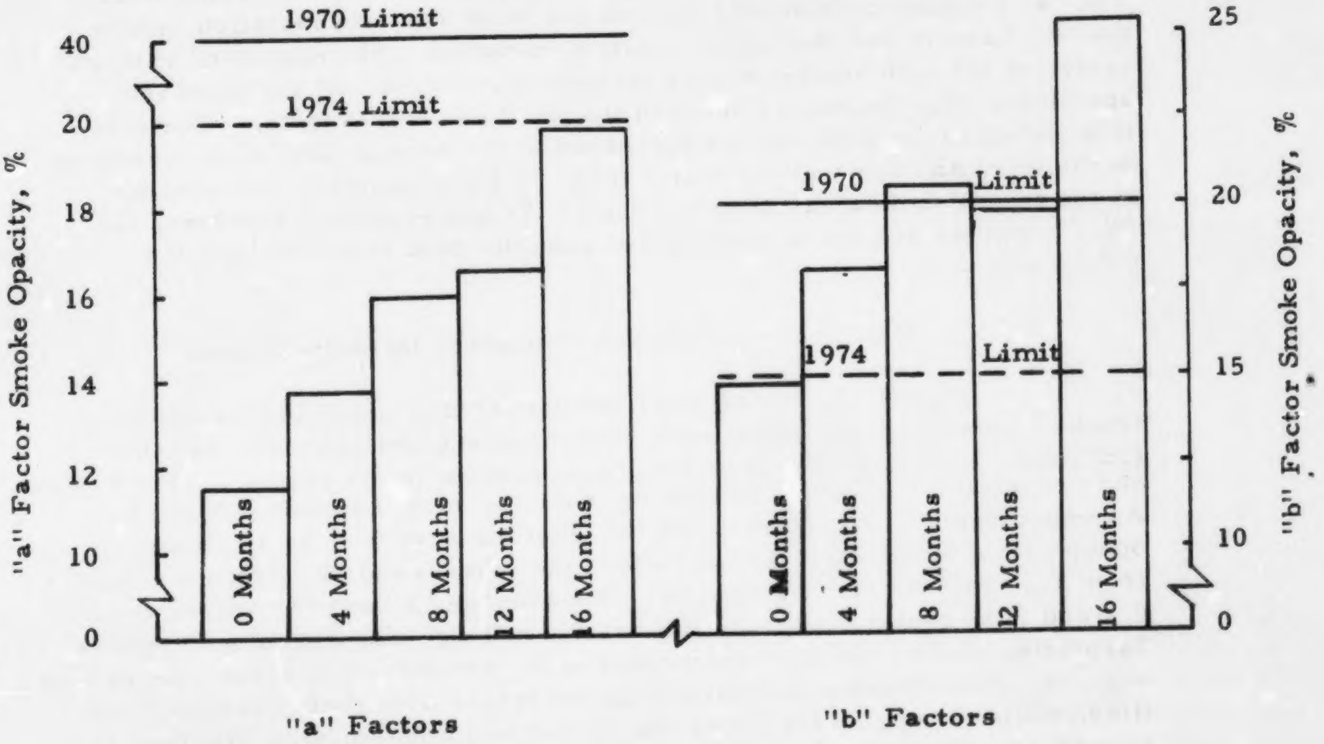


FIGURE 17. AVERAGE "a" AND "b" FACTORS
TEN CUMMINS NHC-250 ENGINES

to a driver complaint of low power. The observed increases in smoke opacity are more difficult to explain. All five of the vehicles involved accumulated substantial mileage between the first and second inspections, and most of the mileage was in very hard intracity service. However, it seems unlikely that mileage alone could account for these large opacity increases. In any case, the engines performed very well, and there appeared to be no noticeable engine deterioration. The average second-round "a" and "b" Factors were 21.4- and 9.9-percent opacity, respectively, which are about 2.5- times the corresponding baseline averages.

The average third-round "a" and "b" Factors were 22.3 and 11.4-percent opacity, respectively, and hence were very close to the averages at the second test. However, even though there were only small changes on the average, there was a large increase and decrease in smoke opacity by two engines, and each change tended to cancel out the other.

Smoke opacity at the fourth round was generally lower than at the third test, although still considerably higher than at baseline. "a" Factors ranged from 14.7 to 18.1, with an average of 16.2, and "b" Factors were 6.9 to 11.6 and averaged 8.0. The fleet owner reported that no engine maintenance was performed between the third- and fourth-round tests; however, some uncertainty exists on this point due to the sketchiness of these records.

The fifth and sixth round results tended to continue the irregular pattern of average "a" and "b" Factors shown by the third and fourth round tests. The "b" factors continued its stairstep upward increase with time through the 24 month program, with the final "a" Factor average of 36 percent relative to a usual 20 percent average for the first year and a half.

The overall increase in "a" and "b" with time is quite evident from Figure 16 and this behavior is quite different from the 71 series Detroit Diesel engines already discussed. This was the only mid-range diesel to complete the 100,000 mile test period in two years and represents an important finding with respect to smoke performance deterioration.

4. Cummins NHC-250 Engine in Intercity Truck-Tractors

An important introductory point should be noted concerning the NHC-250 engines. At one time or other during the first year test period, eight of the ten engines were running fuel delivery (rail) pressures some five to twenty psi (at 2100 rpm and maximum power) over the factory specified 170 to 175 psi. Thus, these engines were fueled at a slightly higher rate than normal. Such an increase in fuel rate usually produces an increase in smoke opacity; however, the amount of this opacity increase cannot be accurately estimated from these surveillance-type tests. This observation, together with the fact that some of these engines had their rail pressures adjusted up and/or down during the test period, led to the conclusion that this data should be presented without special analysis or comments. This approach is further justified on the grounds that an unknown percentage of the NHC-250 engines in use may have had their rail pressures adjusted, it is a very simple and inexpensive operation. The practice of a few owners or operators of NHC-250-powered trucks was to increase the fuel rate (and, hence, the horsepower) when the engine was new or newly rebuilt, then return the fuel rate to normal after a break-in period.

Figure 17 is a bar chart representation of the average smoke factors for the ten intercity tractors powered by the Cummins NHC-250 engine. A steady, mostly consistant increase in both "a" and "b" Factors with time is evident, the exception being the fourth inspection. It should be noted that only three trucks remained in the project for the fifth round inspection and accordingly the average is based on much fewer trucks than previous inspections.

As indicated on Table C-4 (Appendix C), the NHC-250 engines initially demonstrated moderate to high smoke opacity, with "a" Factors from 7.3- to 17.7-percent opacity and "b" Factors from 10.9- to 22.4-percent opacity. Vehicle mileage at the first test ranged from 200 miles to 58,000 miles, and several other trucks had over 30,000 miles. However, the higher-mileage trucks did not necessarily have the highest smoke opacity. At the second- and third-round tests, the majority of the engines had increased opacity over baseline. Four engines had "b" Factors over the 20-percent opacity limit at each of these inspections. Note that the average smoke factors were higher than the baseline averages at the second and third tests.

The fourth-round "a" Factors were in the range of 9.9- to 27.6-percent opacity and averaged 16.5-percent opacity. The corresponding "b" Factors ranged from 12.1- to 31.5-percent opacity and averaged 19.7-percent opacity. Three engines had "b" Factors over the certification limit. Elapsed test mileage after one year of operation was 50,300 to 129,500 miles, and total vehicle mileage at this point was 81,500 to 161,000 miles. None of these engines underwent any maintenance other than routine service.

The three trucks that comprised the fifth round (16 month) inspection reached the mileage for injector maintenance (major tune-up and adjustment) and only this round produced a group "b" Factor (about

25 percent) substantially in excess of the 1970 Federal Limit of 20 percent. The three trucks had "b" Factors of 12.8, 38.5 and 25 percent and this type of variation is greater than normal as shown by the range of values at earlier rounds for the entire ten vehicle group. These three trucks, however, were consistent in their relative differences during third and fourth round testing so their range of values was not a complete surprise.

Simple statistical analysis of these data shows that the dispersion about their respective means was quite large for a group of ten engines, and was much greater than for the two-cycle 6V and 8V engines. In general, the "b" Factors had the greatest amount of absolute dispersion (standard deviation) and the "a" Factors had the largest relative dispersion (coefficient of variation). Both types of dispersion tended to increase with time over the one-year period.

5. Cummins V-903 Engines in Intercity Truck-Tractors

Figure 18 portrays the overall results of this group of truck-tractors. A slight, almost negligible increase in "a" and "b" occurred until the last, 12 month, inspection at which time the average "a" increased by about 4 percent opacity to 14 percent and the "b" increased by about 5 percent opacity to 15 percent. The average lugdown or "b" Factor remained below the 20 percent opacity 1970 Federal Limit.

The V-903 engines included four 240-horsepower models with single exhaust outlet and one 320-horsepower model with dual isolated exhaust stacks. The 240-horsepower rating is obtained by speed derating a 280-horsepower model from 2600 rpm to 2400 rpm. The 240-horsepower rating at 2400 rpm is a standard Cummins option.

Appendix C Table C-5 lists the smoke test results in detail. The five V-903 engines displayed a broad range of smoke opacities at the initial test, with "a" Factors ranging from 2.5- to 18.8-percent opacity and "b" Factors from 3.4- to 18.9-percent opacity. The average first-round smoke factors were about 9-percent opacity. Initial vehicle mileage was 800 to 13,500 miles. On the average, smoke opacity tended to increase slightly over baseline averages at the second and third tests. However, these slight changes in the average opacities were the result of some sharp individual increases and decreases cancelling each other out.

Fourth-round "a" Factors ranged from 8.6- to 19.7-percent opacity and averaged 13.8-percent opacity. The "b" Factors went from 11.4- to 20.2-percent opacity and averaged 15.2-percent opacity. Hence, one engine had lugdown smoke above the 20-percent opacity limit. Elapsed test mileage after one year was 98,500 to 149,800 miles, while total

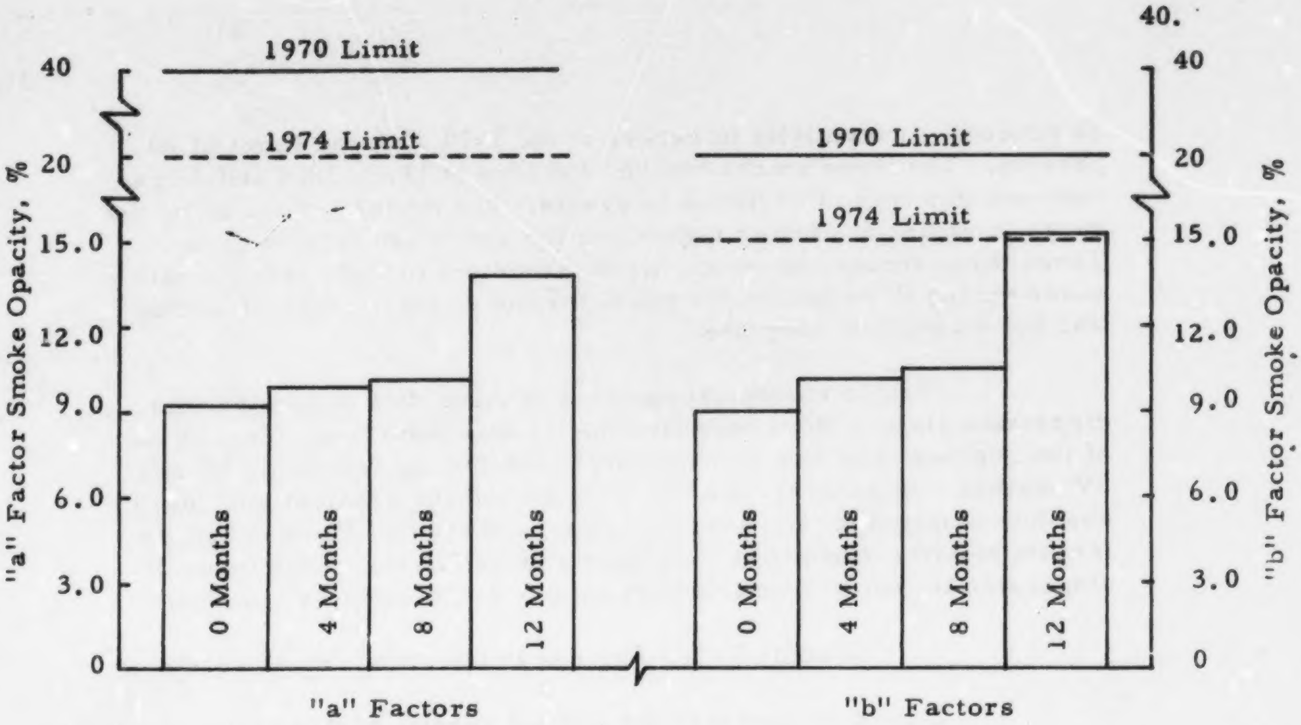


FIGURE 18. AVERAGE "a" AND "b" FACTORS
FIVE CUMMINS V-903 ENGINES

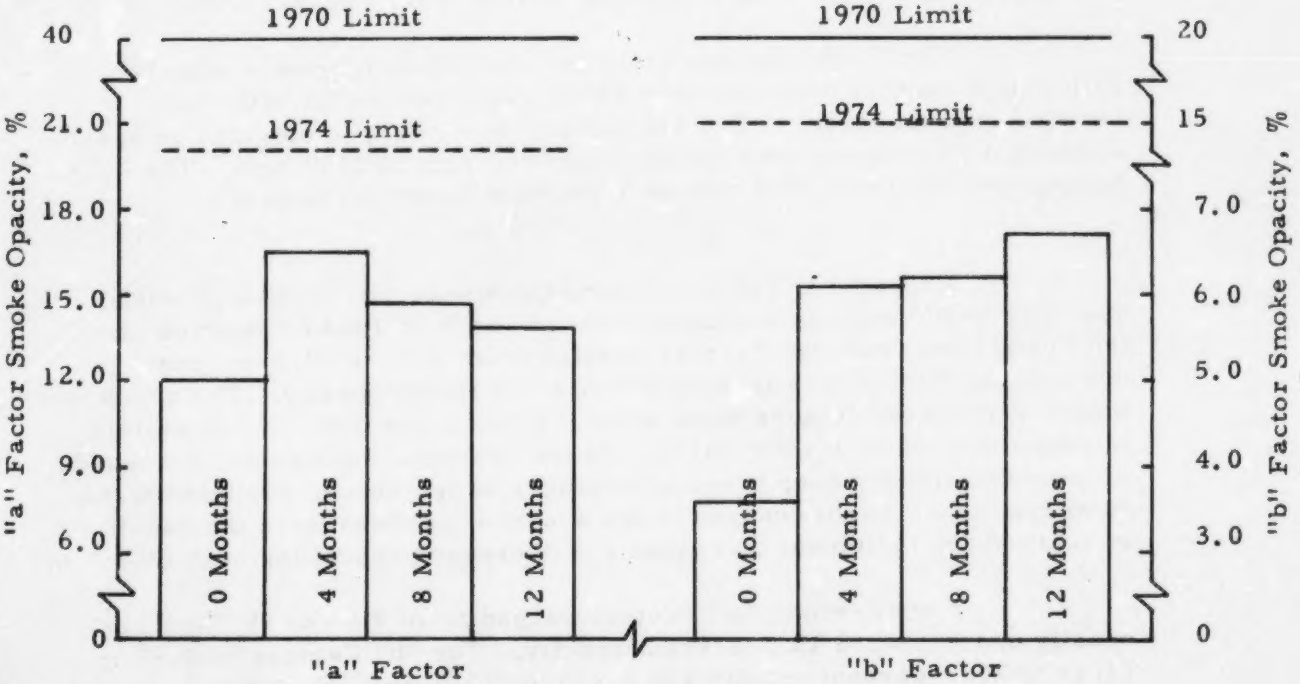


FIGURE 19. AVERAGE "a" AND "b" FACTORS
FOUR CUMMINS NTC-335 ENGINES

vehicle miles at the fourth test was 112,100 to 162,200. No engine maintenance of any consequence was performed during the test period.

The absolute and relative dispersion of these data was greatest at the initial inspection, decreased sharply at the second- and third-round tests, and increased somewhat at the final test. In all cases the "a" Factors appeared slightly more dispersed than the "b" Factors.

6. Cummins NTC-335 Engines in Intercity Truck-Tractors

The Cummins engines tested were of two types, one with 335 horsepower and the other with 280 horsepower. The only difference in the two engines is their fuel rate. Figure 19 depicts the average smoke behavior of this group of four truck-tractors engaged in routine, high mileage, line-haul type operation. The "a" Factor smoke increased and decreased during the 12 months, while "b" Factor increased at the second round test and then remained at a nominal 6.5 percent opacity, a very light, almost invisible exhaust condition. The accel factor was a nominal 15 percent which, for a turbocharged engine is considered good. One truck, unit 144, was lost to the program after two inspections (87,491 miles) due to the owner selling it to a Dallas operator. The averages at the third and fourth inspections are based on three trucks.

From Table C-6, three of the four turbocharged NTC-335 engines had first-round "a" Factors under 10-percent opacity, while the remaining engine was at almost 25-percent opacity. This engine was running with increased fuel pump pressure, similar to several of the Cummins NHC-250 engines. However, the "b" Factors were all very low, from 3.1- to 4.1-percent opacity. Average first-round "a" and "b" Factors were 12.0 and 3.6, respectively. Initial vehicle mileage ranged from 18,600 to 87,400 miles. Smoke opacity generally increased between the first and second inspections, then decreased between the second and third tests. One of the decreases noted at the third-round test was due to tune-up, similar to that previously described, at about 150,000 odometer miles (Truck No. 458). However, the average "a" and "b" Factors at the second and third tests were still slightly higher than at baseline.

Fourth-round "a" Factors were 10.1- to 17.2-percent opacity, and the average was 13.9. These are considered to be low values for turbocharged engines. "b" Factors were also low, ranging from 6.3- to 7.3-percent opacity and averaging just 6.7. Elapsed test mileage for the one-year period was 96,200 to 131,800 miles, and total vehicle mileage at the last test was 128,600 to 219,200.

7. Mack ENDT 675 Engines

The two-truck-tractors powered by Maxidyne engines came into the project with high mileage, over 67,000 and 70,000 miles, respectively. The average results are graphed in Figure 20 from data contained in Table C-6. The first-round "a" Factors were 26.5- and 28.7-percent opacity, and the corresponding "b" Factors were only 7.6- and 6.5-percent opacity. Second-round smoke opacity was considerably higher than baseline, and one "a" Factor was over the 40-percent opacity limit. A drop in opacity occurred between the second and third inspections, but the smoke factors were still above baseline values. The opacity decreases were due to engine tune-ups performed at approximately 125,000 odometer miles. Such a major tune-up usually consists of removing and cleaning injectors, setting valve clearances and injection timing, and adjusting the injection pump to obtain proper fuel delivery rate.

Fourth-round "a" Factors were 44.7- and 36.8-percent opacity, with an average of 40.8, while "b" Factors were 13.6- and 10.5-percent opacity and averaged 12.0. Elapsed test mileage was 137,700 and 124,400, and total vehicle mileage at the end of the test was 205,100 and 194,700.

8. Mack ENDT 675 Engines in Commercial Garbage Trucks

This group of engines includes five Mack ENDT 675 ("Maxidyne") engines engaged in intracity operated commercial garbage disposal trucks of a very large and heavy type. This type of operation was characterized by repetitive accel-decel in the stop and go type of service that in its way may be considered much more severe than most line-haul intercity type operation.

Figure 21 summarizes the average smoke factors, listed in detail in Table C-7, for the entire 24 month surveillance project. As more operating time and mileage was accumulated, exhaust smoke opacity steadily increased, with one major exception at the final test. Deterioration of the initial smoke performance was dramatic and quite evident in Figure 21 with a three-fold increase in the average "a" Factors (from 19 to 56 percent opacity) and in the average "b" Factors (from 7 to 25 percent opacity). Two of the trucks were eliminated from the surveillance testing due to a fire which totally destroyed Unit 2 after the fourth round and a major accident to Unit 5 shortly before the final inspection. Thus the fifth and sixth rounds are averages of four garbage trucks, while the final inspection, seventh round, is based on three of the original five trucks.

The Maxidyne engines had smoke output typical of most turbocharged engines, i.e., high smoke peaks during accelerations and low smoke opacity under high power steady-state (or quasi-steady-state) operation, as listed on Table C-7. First-round "a" Factors were 14.8- to 25.6-percent opacity, with an average value of 19.2, while the "b" Factors ranged from 4.1- to 12.0-percent opacity and averaged 7.4. Four of the garbage trucks had low initial mileage (1400 to 5000 miles) and one had over 28,500 miles. Again, the vehicle with the highest mileage

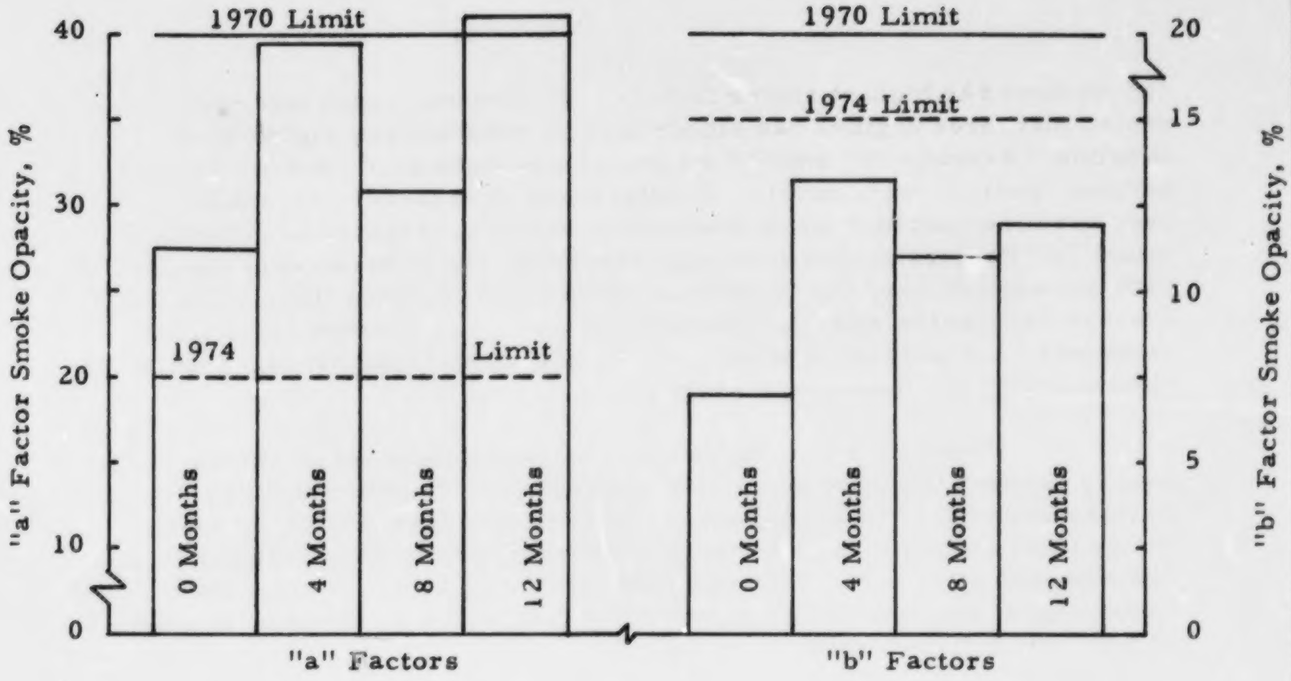


FIGURE 20. AVERAGE "a" AND "b" FACTORS
TWO MACK ENDT 675 INTERCITY ENGINES

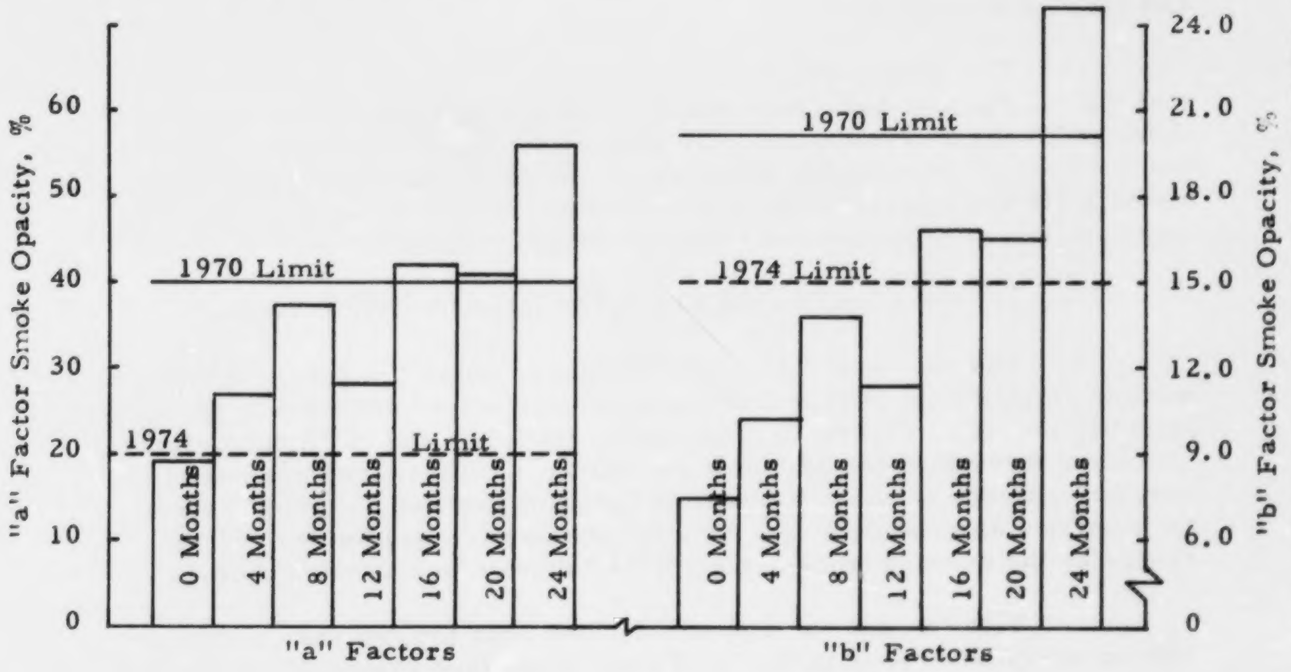


FIGURE 21. AVERAGE "a" AND "b" FACTORS
FIVE MACK ENDT 675 INTRACITY ENGINES

did not have the highest smoke factors. The second-round test revealed that three engines had smoke factors substantially higher than baseline. Average "a" and "b" Factor values were 27.0- and 10.1-percent opacity, respectively. Similar--and even larger--increases over baseline opacities were observed at the third inspection. Third-round "a" Factors ranged from approximately 30- to 44-percent opacity, with two engines over the 40-percent opacity certification limit. The average "a" Factor was 37.3-percent opacity. The average "b" Factor value was 13.9-percent opacity. Hence, the third-round averages were almost double the first-round averages.

However, three engines had marked decreases in smoke opacity between the third and fourth inspections. Fourth-round "a" Factors were 25.2- to 29.8 -percent opacity, and averaged 28.0, while "b" Factors ranged from 9.5- to 13.3-percent opacity and averaged 11.5. The fifth and sixth round data per Table C-7 were almost equivalent though higher than the fourth round and in line with the trend established by previous test intervals.

Elapsed test mileage for the two years was 72,000 to 84,000 miles, and total vehicle mileage at the last inspection was 60,000 to 100,000 miles. While these mileage figures are not high when compared to those of the intercity vehicles, the garbage trucks are subjected to very severe service, and mileage is therefore not necessarily an indication of the wear-and-tear on the engines.

The simple statistical analysis performed on these data shows that the "a" Factors had a high degree of absolute dispersion at the first three and last three tests, but very little at the fourth inspection, while the "b" Factors were highly dispersed at the first, third, fifth and sixth-round tests and more closely grouped at the second and fourth tests. The relative dispersion of the data followed similar trends.

9. Mack ENDT 673B Engines in Intracity Truck-Tractors

The two Mack ENDT 673B engines, which comprised this group, were in small 2 axle (single drive axle) truck tractors and were engaged in intracity service. Figure 22 shows the average "a" and "b" smoke values measured throughout the 24 month surveillance. These tractors were in very low mileage service, but still operated in stop and go traffic as well as freeway - arterial driving. Although the service was not termed as severe as the garbabe trucks, the smoke behavior was somewhat similar.

Both "a" and "b" Factors doubled over the two year period with an unexplained peak in the "a" Factor trend (see Figure 22) at the fifth round inspection. From Table C-7, the two 673B engines had first-round "a" Factor values of 15.2- and 7.7-percent opacity, and "b" Factor values

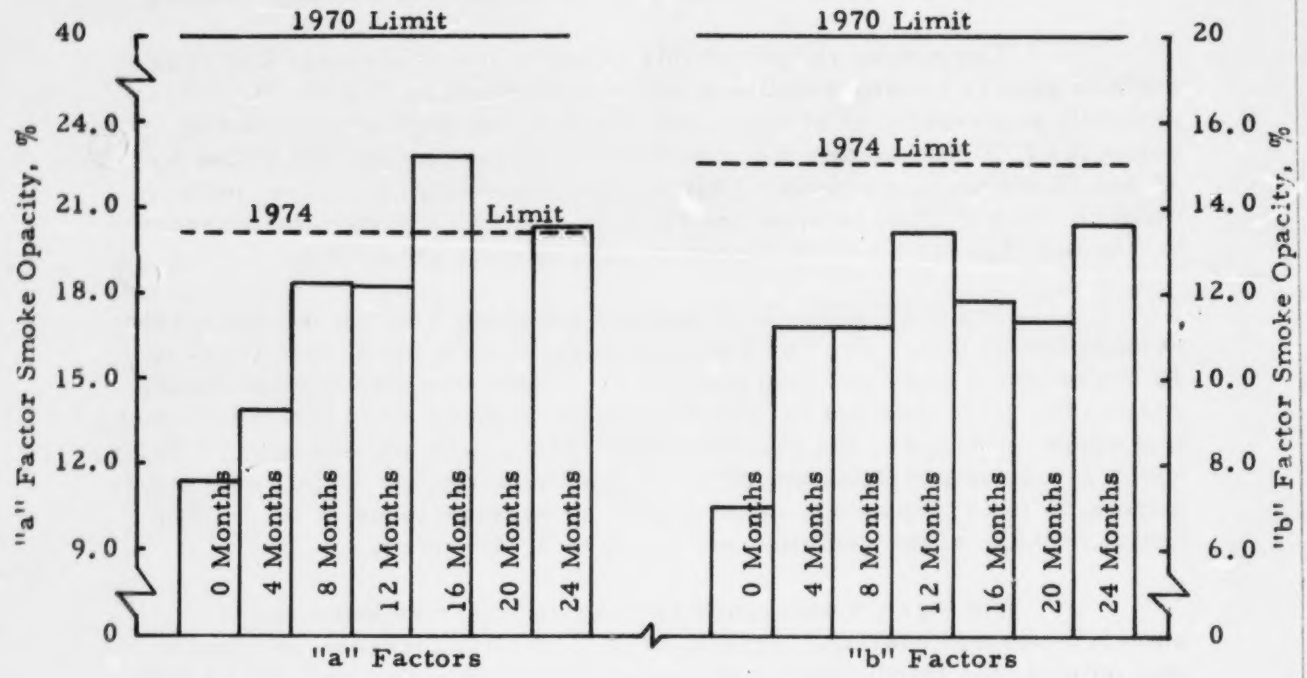


FIGURE 22. AVERAGE "a" AND "b" FACTORS
TWO MACK ENDT 673B ENGINES

of 7.4- and 6.5-percent opacity. Initial vehicle mileages were about 4800 and 6300 miles. Smoke opacity at the five subsequent inspections was higher than baseline for both engines. Seventh-round "a" Factors were 26.4-and 14.2- percent opacity, and "b" Factors were 20.2- and 7.0-percent opacity. Elapsed test mileage after the two years was 26,965 and 27,546 miles, and total vehicle mileage was 31,703 and 33,852.

10. Caterpillar Midrange 1145 Engines in Intracity Trucks

The smoke results of this group of five mid-range Cat 1145 engines used in beverage delivery are summarized on Figure 23. These naturally aspirated four stroke cycle engines had difficulty in staying below the 1970 "b" Factor Federal limit of 20 percent opacity at the 8, 12 and 20 month inspections. Unlike some other engine groups, no long term "b" factor trend is apparant from Figure 23, although the increase in "a" factor through the first twenty months is quite consistant.

The Caterpillar 1145 engines generally had low smoke opacity at their initial test. The "a" Factors (Table C-8) ranged from 13.0- to 16.2-percent opacity and averaged 14.6. There was a very brief smoke peak of 50- to 70-percent opacity during the first acceleration of the smoke test cycle. However, the brief duration of this peak allowed the "a" Factor, which is a time-averaged quantity, to remain fairly low. The "b" Factors were 8.5- to 14.5-percent opacity, with an average value of 10.7. The initial mileage of the vehicles was 2,000 to 5,800 miles.

Average second-round "a" and "b" Factors were 16.9- and 15.5-percent opacity, respectively. A further increase in opacity was noted at the third-round test, where the average "a" and "b" Factors were 22.1 and 21.1, respectively. Two engines had "b" Factors above 20-percent opacity. For the fourth-round test, "a" Factors ranged from 18.4- to 29.6-percent opacity and averaged 24.7, while "b" Factors were 19.6 to 33.4, with an average of 25.4. Four of the five "b" Factors were above the 20-percent opacity limit. The fifth-round or 16 month inspection "a" Factors ranged from 15.4 to 27.2 (average of 23.2) and "b" Factors ranged from 10.8 to 22.8, average of 18.5 percent opacity. The sixth-round had a range from 13.1 to 37 percent "a" (average of 26.6), while the "b" varied from 12.2 to 35.9 (average of 21.5) percent opacity. For some unexplained reason, the smoke at the seventh round decreased to average "a" of 20.0 (18.3 to 21.3) and an average "b" of 17.6 (14.4 to 19.7) percent opacity. Elapsed test mileage was quite varied, with a low of 14,594 miles and a high of 61,666, and total vehicle mileage at the last test was 16,981 to 67,497.

11. Caterpillar Midrange 1150 Engines in Intracity Truck-Tractors

This group of engines were quite similar to the five 1145 series

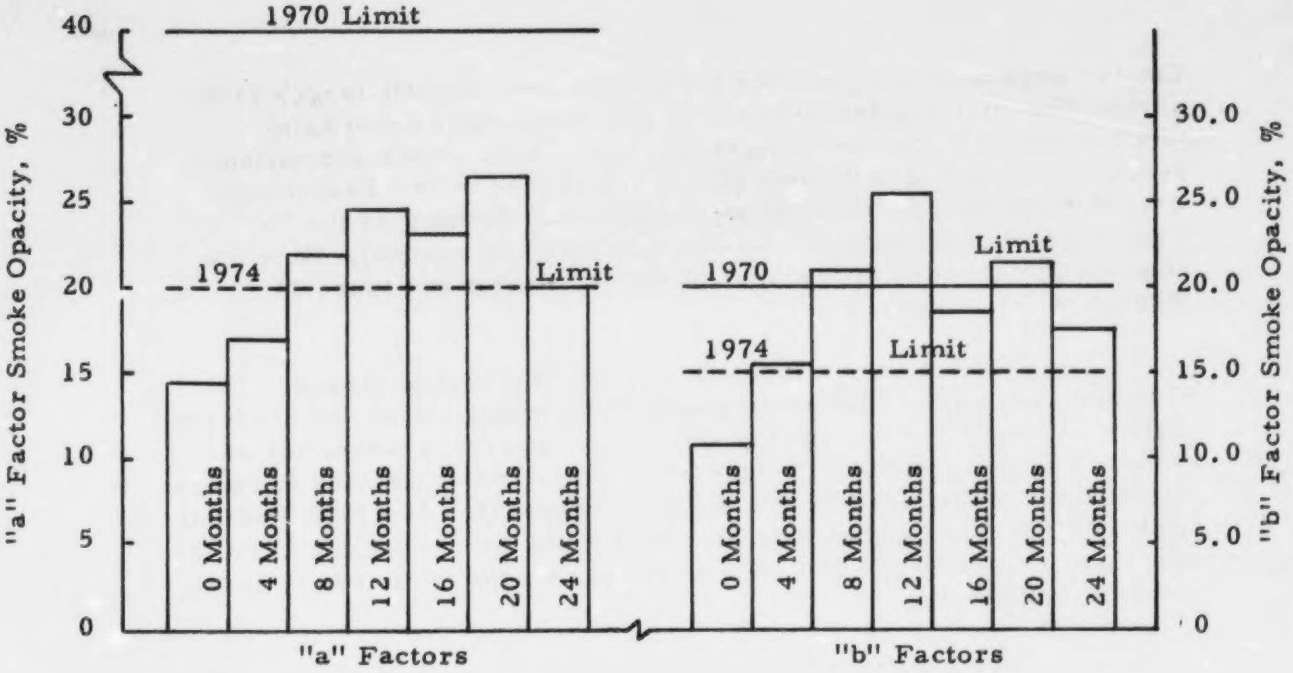


FIGURE 23. AVERAGE "a" AND "b" FACTORS
FIVE CATERPILLAR 1145 ENGINES

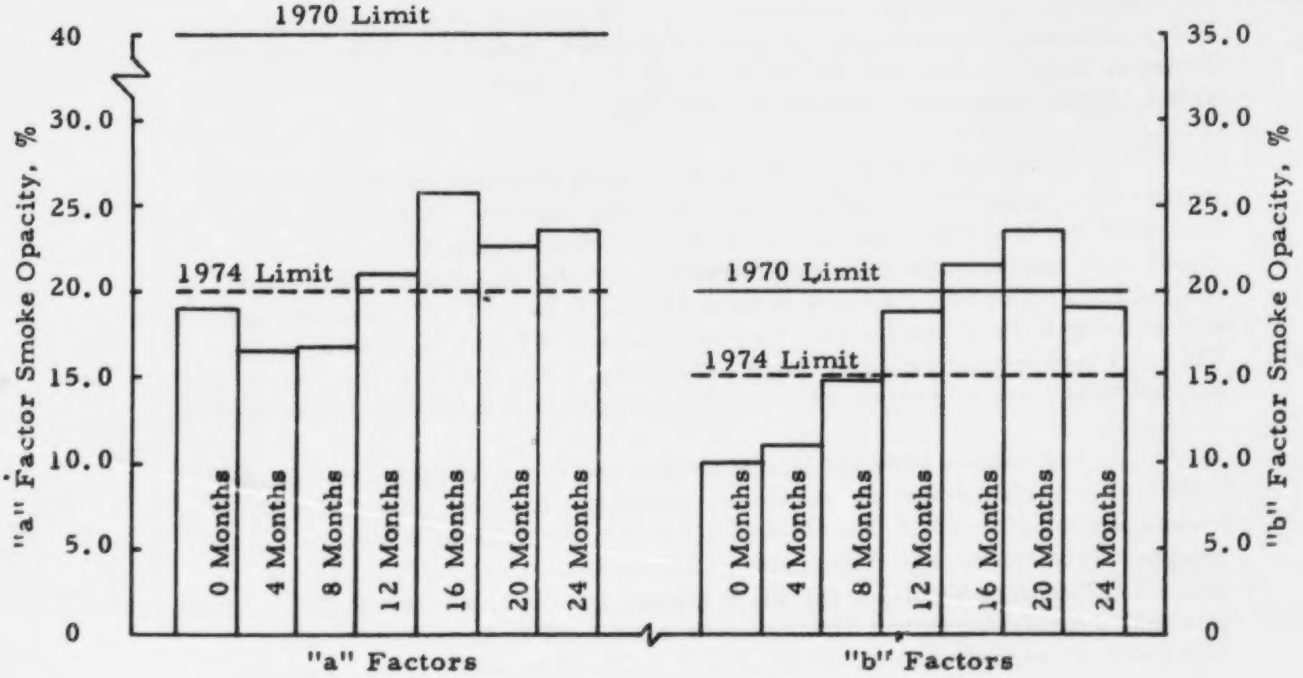


FIGURE 24. AVERAGE "a" AND "b" FACTORS
FIVE CATERPILLAR 1150 ENGINES

Cat 175 engines in the previous group, but were slightly larger 1150 series (Cat 200) engines operated in two axle (single drive axle) truck-tractors in general freight service. Their smoke surveillance results are graphed in Figure 24. The increase in "a" Factor with time is much less pronounced than the overall doubling of the "b" Factor (from about 10 to 20 percent opacity in 24 months). Note the consistant stair-step appearance of the "b" Factor in Figure 24 through the first 20 months.

Table C-9 is a tabulation of the results and ranges. The 1145 and 1150 engines differ mainly in their power output and produced smoke "a" and "b" Factors that were quite similar in magnitude and trend. The two groups of engines were in dissimilar service and were operated and maintained by two different concerns. The 1970 Federal limit of 20 percent opacity was exceeded at the fifth and sixth round inspections on an average and by one or more trucks at the fourth and seventh round tests.

These engines had first-round "a" Factors of 15.5- to 25.7-percent opacity and "b" Factors from 7.0- to 15.6-percent opacity. The average "a" and "b" values were 18.8 and 10.0, respectively. As in the case of the Cat 1145 engines, there was a brief smoke peak during the initial acceleration of the test. This peak was of 75- to 95-percent opacity, but its effect on the time-averaged "a" Factors was small. The 18.8 percent "a" Factor contained a "c" Factor of 58 percent opacity, which indicates the severity of the brief smoke peak noticed. The 1974 Federal limit for the "c" factor is 50 percent opacity. Vehicle mileage at the initial test was 7,600 to 13,100 miles.

Second-round "a" Factors were generally lower than at the initial test, while "b" Factors were slightly higher. One engine (in Truck No. 880) received an adjustment to its injection pump after the first-round test and showed greatly decreased smoke opacity at the second inspection. The "a" Factors ranged from 15.2- to 17.7-percent opacity, and averaged 16.4, while "b" Factors were 8.8 to 13.4, and averaged 11.1. Third-round "a" and "b" Factors were slightly higher than at the second test, and averaged 16.6- and 14.7-percent opacity, respectively.

Another general increase in opacity occurred between the third- and fourth-round inspections. Average fourth-round "a" and "b" values were 21.0 (16.5-25.4)- and 18.8 (13.7-22.3)-percent opacity, respectively. Average fifth, sixth and seventh-round "a" Factors were 25.7 (range 22.2-29.5), 22.8 (range 20-28.2) and 23.5 (19.1-29.7) percent opacity while the "b" Factors continued to increase to 21.4 (14.2-25.6) at fifth round, to 23.5 (17.2-30.3) at sixth round and then decrease to 19.0 (12.6 to 24.2) at the final inspection. Elapsed test mileage for the year's operation were 19,722 to 29,696, and total vehicle mileage at the last test ranged from 27,443 to 37,346.

12. GM Mid-range DH-478 Engines in Intracity Truck-Tractor

The average "b" Factor of four GM DH-478 four stroke cycle naturally aspirated mid-range diesel powered truck-tractors (two axle single drive axle) quickly reached the 1970 Federal limit of 20 percent opacity according to Figure 25. The lug-down "b" increased from the initial 9 percent to the nominal 20 percent, i.e., doubled, by the 8 month inspection and then stayed at this level, more or less for the remainder of the test. The "a" Factors, per Figure 25, also doubled over the course of the two year period (from about 7 to 17 percent.

Table C-10 lists the detailed test results by round. First-round smoke opacity for these engines was low, with "a" Factors from 5.1- to 8.9-percent opacity and "b" Factors from 6.5- to 11.6-percent opacity. The respective averages were 7.3 and 9.2. Initial vehicle mileage was 760 to 7,100 miles.

An opacity increase for all four engines was registered at the second inspection. The average "a" and "b" values remained low, however, just 11- and 13-percent opacity, respectively. Another, somewhat larger, increase was generally noted at the third-round test. In particular, the engine in Truck No. 137 had smoke factors approximately five times higher than at baseline. Some component of the injection system was probably out of adjustment. In any case, three of these engines had "b" Factors at or above 20-percent opacity. Average third-round "a" and "b" values were 16.7 and 22.4, respectively.

Fourth-round smoke factors were lower than at the third inspection, but still substantially over the corresponding baseline values. The "a" Factors at the last inspection ranged from 8.6- to 24.0-percent opacity, and averaged 14.1, while "b" Factors ranged from 12.1 to 28.5, with an average of 18.5. These averages were about twice those of the initial test. The engine in Truck No. 190 received an injection pump adjustment prior to the fourth-round test; however, the maladjusted engine in Truck No. 137, for some inexplicable reason, received no attention.

The fifth-round "a" was an average of 16.6 (range 11.7 to 20.6), sixth - round "a" was an average of 15.9 (range 8.0 to 22.9) and the final test "a" was 17.7 (range 11.0 to 26.4)-percent opacity. Average "b" Factors at fifth-round was 20.1 (range 13.7 to 30.1), at sixth-round was 18.8 (range 10.8 to 26.5) and at seventh-round was 20.3 (range 12.0 to 29.4)-percent opacity. After two years of operation, these vehicles had accumulated 21,877 to 35,971 test miles, and total vehicle mileage at the last inspection was 22,874 to 43,105 miles.

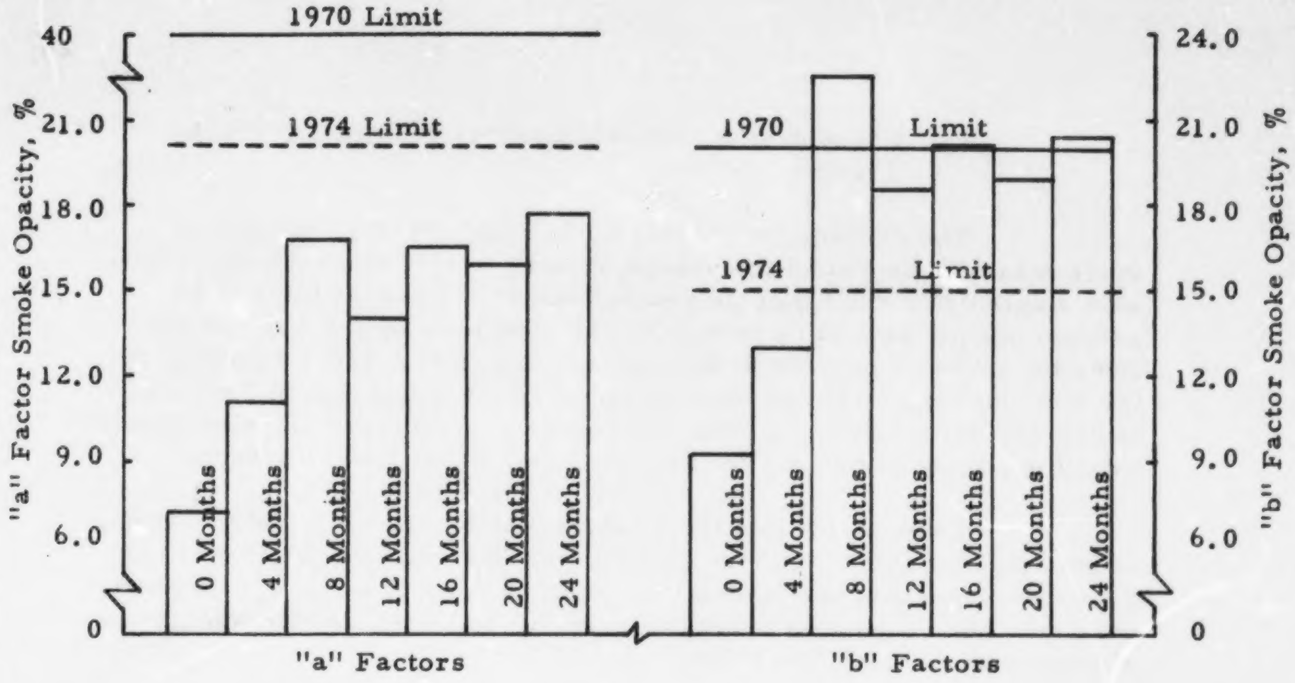


FIGURE 25. AVERAGE "a" AND "b" FACTORS
FOUR GM DH-478 ENGINES

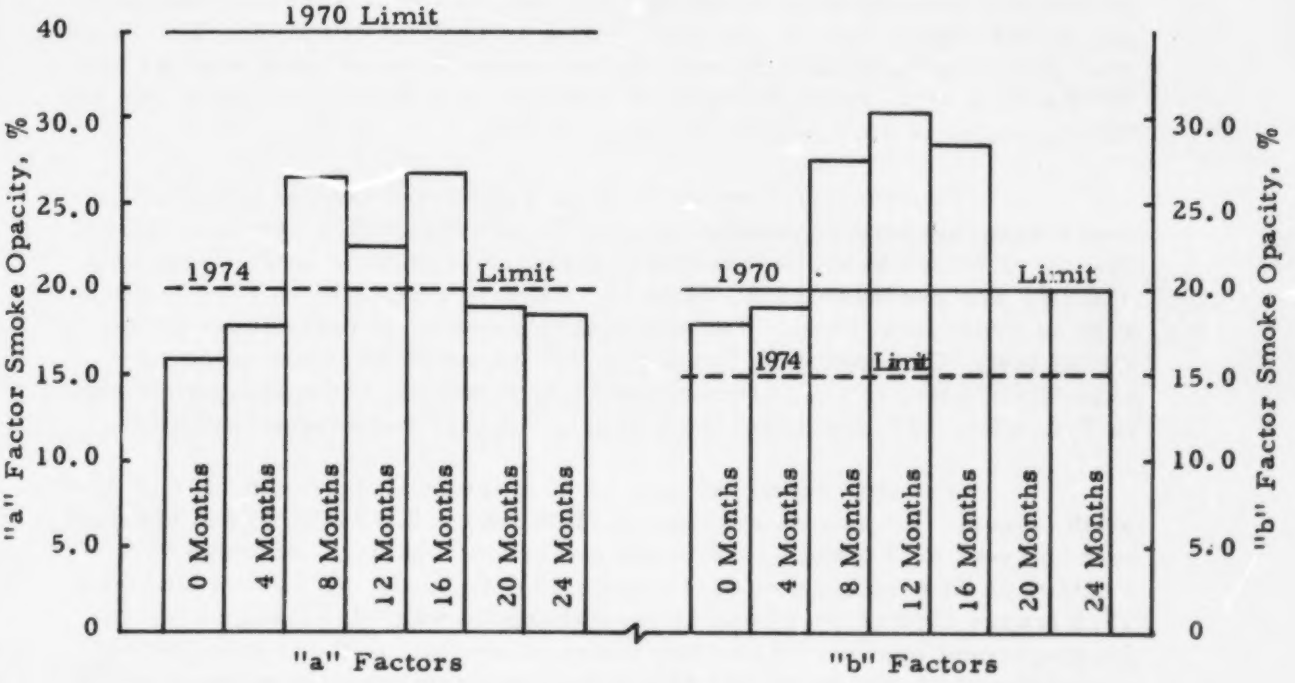


FIGURE 26. "a" AND "b" FACTORS
ONE INTERNATIONAL HARVESTER DV 550B ENGINE

13. International Harvester DV 550B Engine-Dump Truck

Figure 26 shows the "a" and "b" smoke behavior of the IHC DV550B powered dump truck. For more than half the two year period, this engine exhibited substantially higher than the 1970 Federal limit lugdown or "b" smoke. The accel factor was likewise considered high for a naturally aspirated engine even though below the 40 percent "a" factor limit.

From Table C-10, the first-round "a" and "b" Factors were 15.9- and 17.9-percent opacity, respectively, and initial vehicle mileage was 10,000 miles. A slight increase over this baseline opacity was registered at the second test, and a much greater increase noted at the third inspection. At that time the "b" Factor was over 20-percent opacity. Fourth-round "a" and "b" values were 22.4 and 30.3, respectively The fifth-,sixth- and seventh-round "b" Factors 28.5, 14.9 and 20.2-percent opacity respectively. Elapsed test mileage was 39,379 and total vehicle mileage was 49,408. An engine tune-up, performed between the fifth and sixth inspection, was apparently the reason for the lower smoke at the last two tests.

B. Smoke Results by Odometer Miles

This subsection summarizes the entire two year surveillance project in terms of odometer miles. For this purpose, the "a", "b" and "c" Factors for each engine-vehicle have been computer plotted against odometer readings in miles.

Since a few very high mileage vehicles approached an odometer reading of 180,000 miles, this was used as a common length. Most vehicles either reached 100-125,000 miles or were substantially below 100,000 miles. The graphs show not only the smoke with odometer reading but, taken as a group, the gross differences in mileage accumulated.

Appendix D contains 64 graphs, one for each vehicle. To summarize this data, the 13 groups discussed in the previous subsection, were plotted as a function of odometer mileage and are discussed in the text. Please refer to Appendix D for individual plots. In most instances, the trends in data are similar, if not identical, to that already presented.

1. Detroit Diesel 6V-71N Engines in Intracity Buses

Figure 27 shows the results of this 10 bus group. In addition to comments made earlier about their very low smoke levels, the group as a whole exhibited very similar trends such that the tight grouping of the points results. The smoke from two buses, numbers 817 and 818 seemed to compensate for one another during the latter part of test with 817 going down and 818 going up. Otherwise, there were no trends of any consequence. The buses started low and for the most part stayed low.

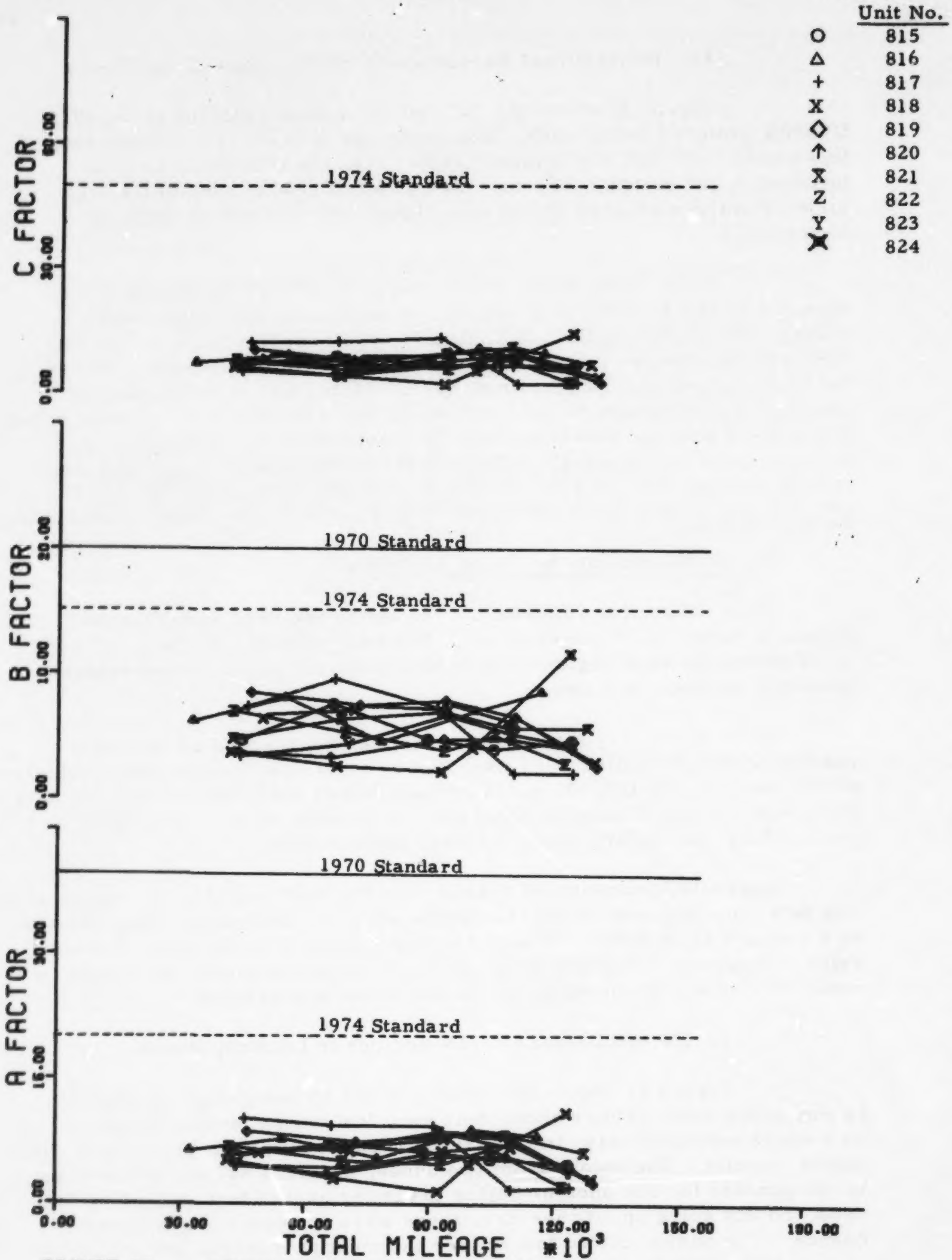


FIGURE 27. DETROIT DIESEL 6V-71N ENGINES IN INTRACITY BUSES
(Operated on DF-1 Fuel)

2. Detroit Diesel 8V-71N Engines in Intercity Service

Figure 28 depicts the behavior of the five truck-tractors, each equipped with dual exhausts (left and right bank of the engine) and the one intercity bus. Although not as low in smoke as the smaller 6V-71 engines in the city buses operating on a size 60 injector and a lower smoke fuel, DF-1 or kerosene-like fuel, the affect of miles had only a very slight effect on smoke. As with the city buses, the deterioration of the "a" and "b" factors was quite small and easy to justify in terms of injector wear, etc.

It is uncertain how future surveillance type projects should treat the dual exhausts where each handles a separate portion of the engine. The use of two smokemeters at the same time is practical, but leaves some question as to what to do with the results. Should both stacks be treated separately or should the smoke factors be calculated for both stacks and then averaged to get a final number?

Except for the left bank of unit 104 and the unit 591 intercity bus, which had smoke factors higher than the remainder, the data was closely packed as with the city bus engines and well below the 20 percent "b" and 40 percent "a" Factors throughout the surveillance period.

3. Detroit Diesel 6V-53N Engines in Intracity Trucks

The greatest increase in visible smoke with this group of smaller displacement and higher engine speed two-stroke cycle engines occurred during the first year between the initial and second or third (about 30,000 miles) inspection. As shown by Figure 29, from there until the final inspection at about 100,000 miles, the smoke remained fairly stable "a" of 20 and "b" of 10 percent opacity.

The last test on unit 8 was found to be in error and was deleted due to a faulty throttle system which gave exceptionally low power and smoke. The other four trucks were consistent in exhausting higher smoke levels at the final inspection than at the previous test.

The significant increase early in the test could well be the normal characteristic for this engine. The final upswing, at the conclusion of the surveillance project, could be attributed to the need of engine maintenance,as about 110,000 miles had been accumulated at that time. In any event, this group of mid-range engines exhibit a different smoke behavior with mileage than the larger "71" series two-stroke engine in trucks and buses. Smoke levels were higher and change with mileage (deterioration) was greater than the larger, slower rotating speed engine.

4. Cummins NHC-250 Engines in Intercity Truck-Tractors

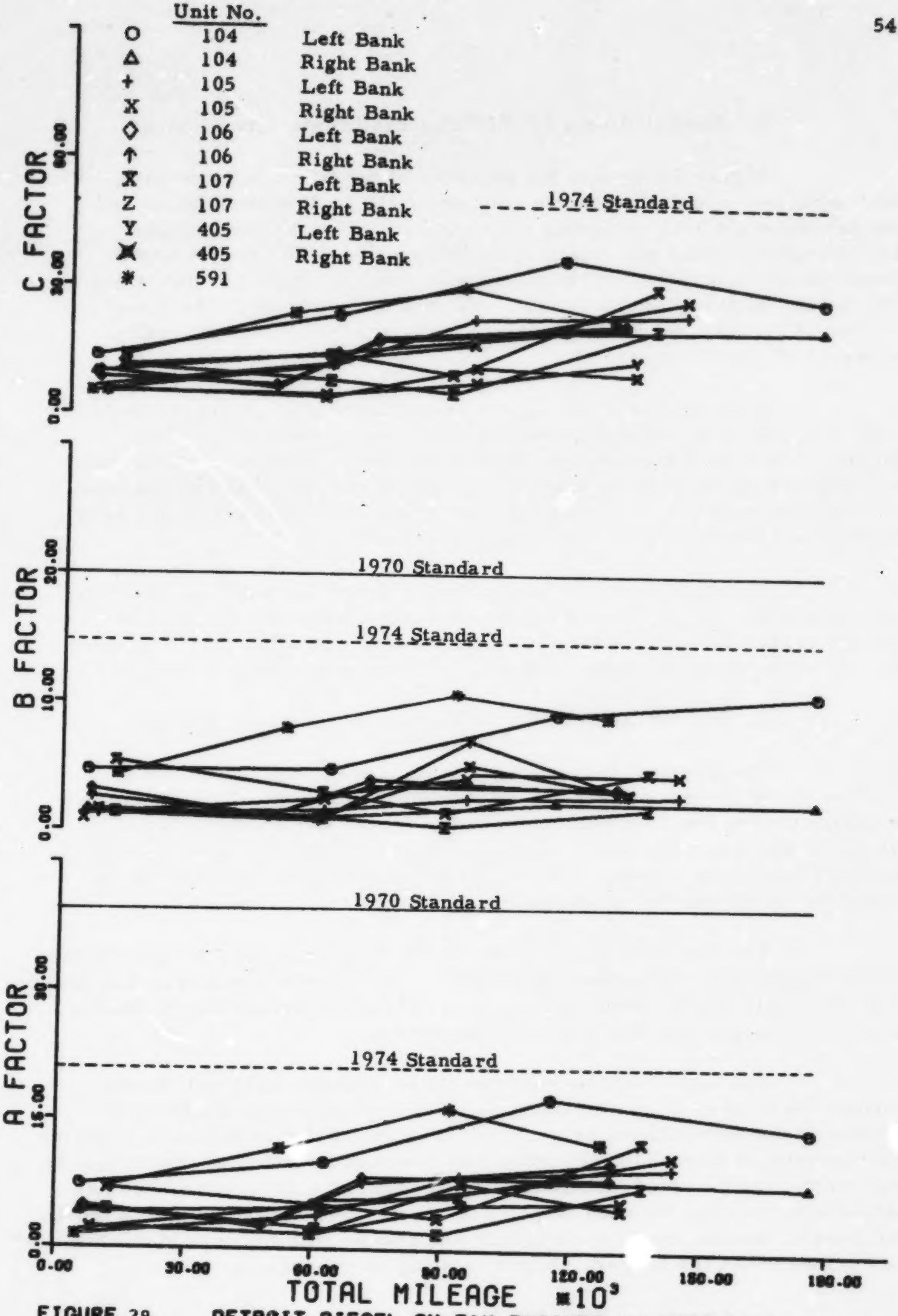


FIGURE 28. DETROIT DIESEL 8V-71N ENGINES IN INTERCITY SERVICE

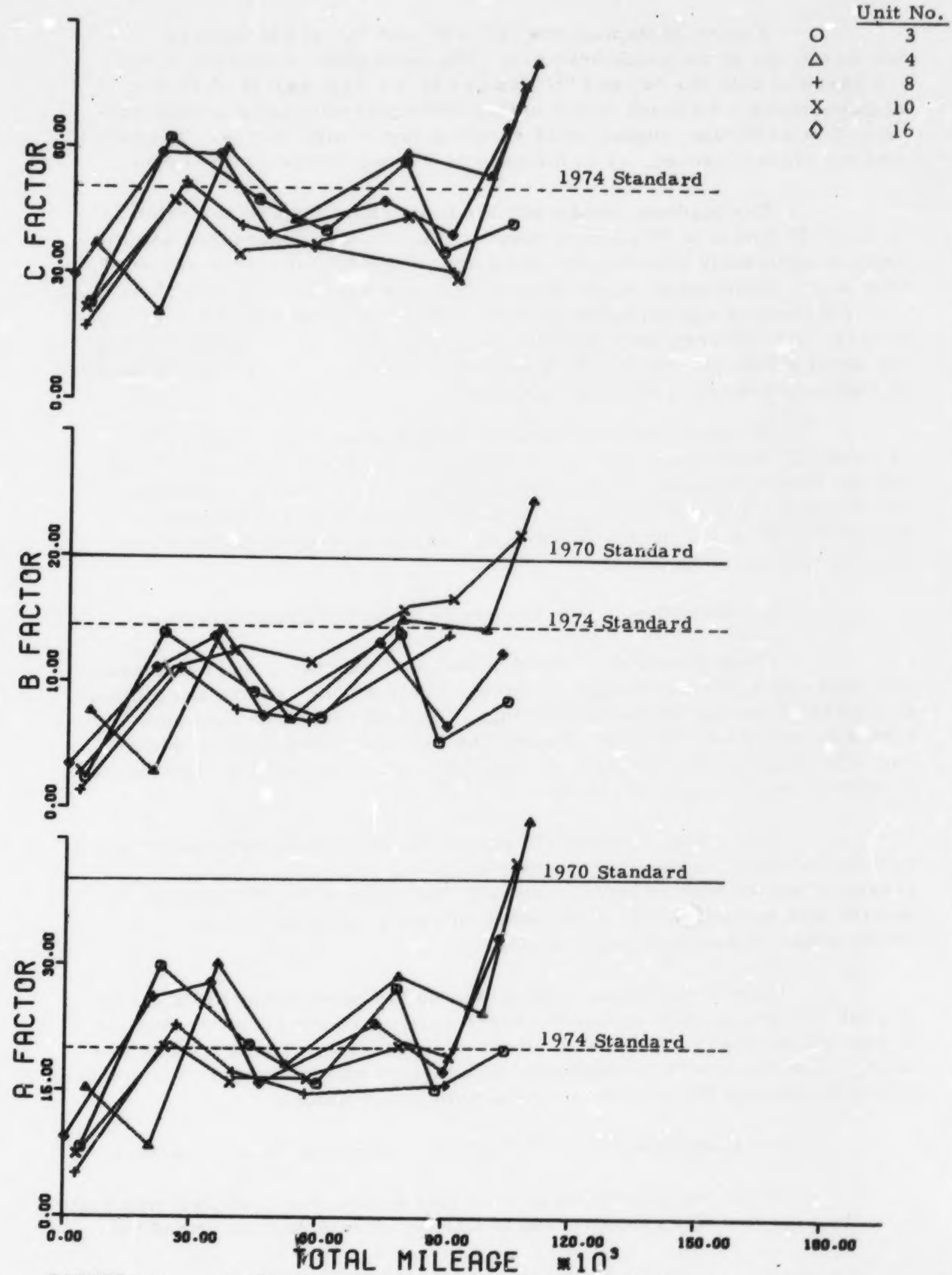


FIGURE 29. DETROIT DIESEL 6V-53N ENGINES IN INTRACITY TRUCKS

Figure 30 depicts the "a", "b" and "c" smoke factors for this group of ten truck-tractors. The variability of results, i.e., the range of both the "a" and "b" factors is the first aspect of Figure 30 of importance. As much or more than other intercity units in this project, this particular engine could result in low to high values. The data was not closely packed, as in the case of the two stroke cycle engines.

The lugdown smoke was the most significant factor relative to the 1970 limits of 20 percent opacity. As the test progressed and the engines apparently deteriorated in smoke, a number of trucks exceeded this limit. Admittedly, some were in fuel rate specification and some were not, but those in specification were not necessarily the lower smoke producers. As has been the experience in past programs involving this engine, the accel smoke factors can be predicted from the steady state like lugdown, in that they are approximately equivalent.

Overall, the effect of increasing mileage was increased "a" and "b" smoke at a rate quite similar to intercity operated 8V-71N Detroit Diesel engines. These two engines were in quite comparable service and represent the majority of all engines in use in line-haul operation and by far the majority of all naturally aspirated diesel engines in intercity service.

5. Cummins V-903 Engines in Intercity Truck-Tractors.

These five units, Unit 415 had dual exhausts, were in identical intercity scheduled freight service. Their smoke results are plotted in Figure 31 versus odometer readings. As with the other Cummins naturally aspirated NHC-250 engine, the "b" smoke factors are quite variable ranging from about 5 up to 20 percent. The left and right banks of unit 415 were almost identical.

Two units, 968 and 972 stayed fairly constant between 15 and 20 percent "b" factor throughout the test while the others demonstrated an increase in smoke with mileage. Overall, the slope of the "a" and "b" factors are not unlike that of the other intercity operated two and four stroke cycle engines discussed so far.

None of the engines discussed so far have exhibited "a" accel or peak "c" smoke of particular concern relative to the 1970 "a" limit of 40 percent smoke or the 1974 "c" limit of 50 percent. These factors are mostly of concern with the turbocharged engines where acceleration smoke normally exceeds the lugdown or maximum power smoke.

6. Cummins NTC-335 Engines in Intercity Truck-Tractors

Of the four truck-tractors in this group, one (unit 144) was lost from the program when transferred to Dallas. The data from it and the

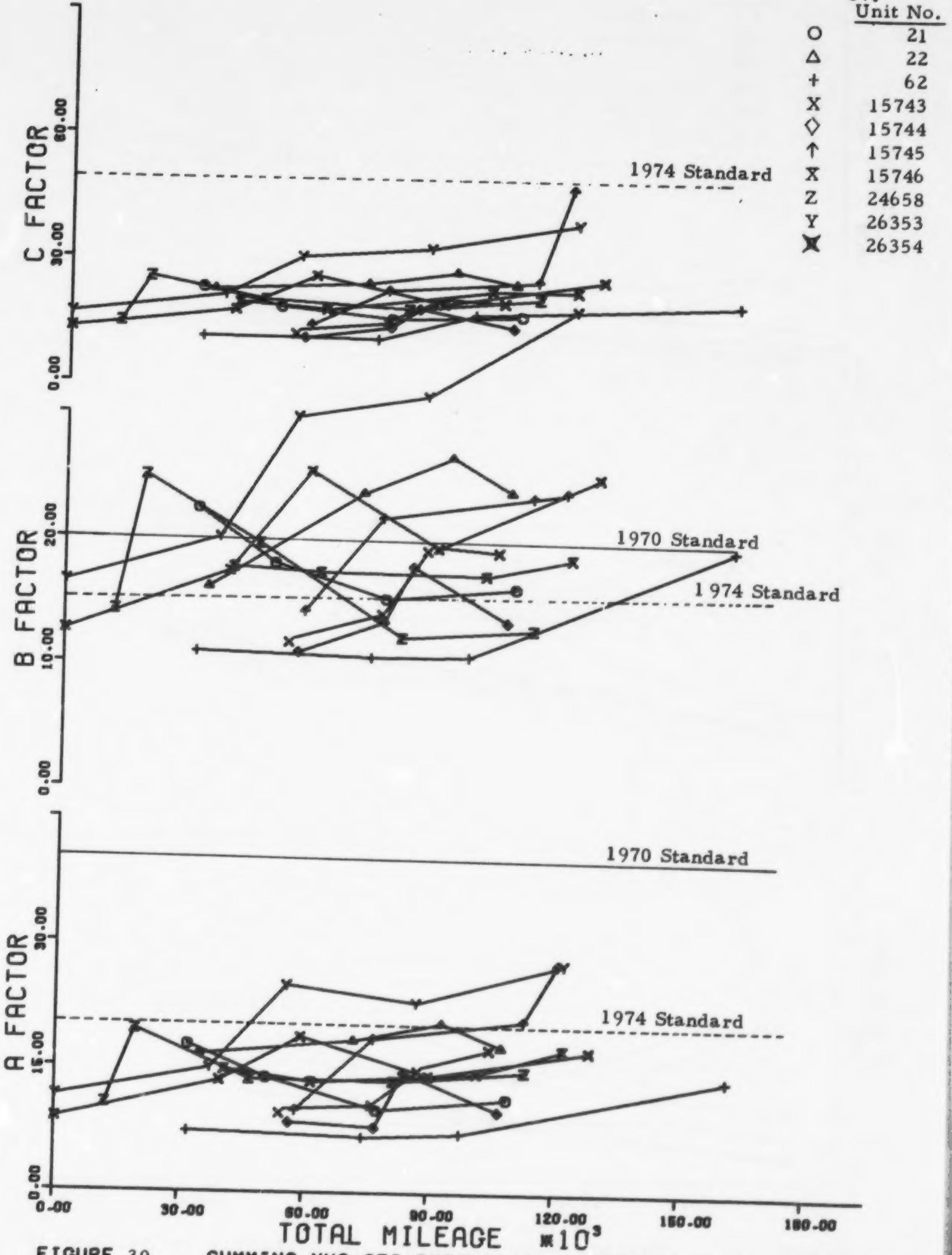


FIGURE 30. CUMMINS NHC-250 ENGINES IN INTERCITY TRUCK-TRACTOR

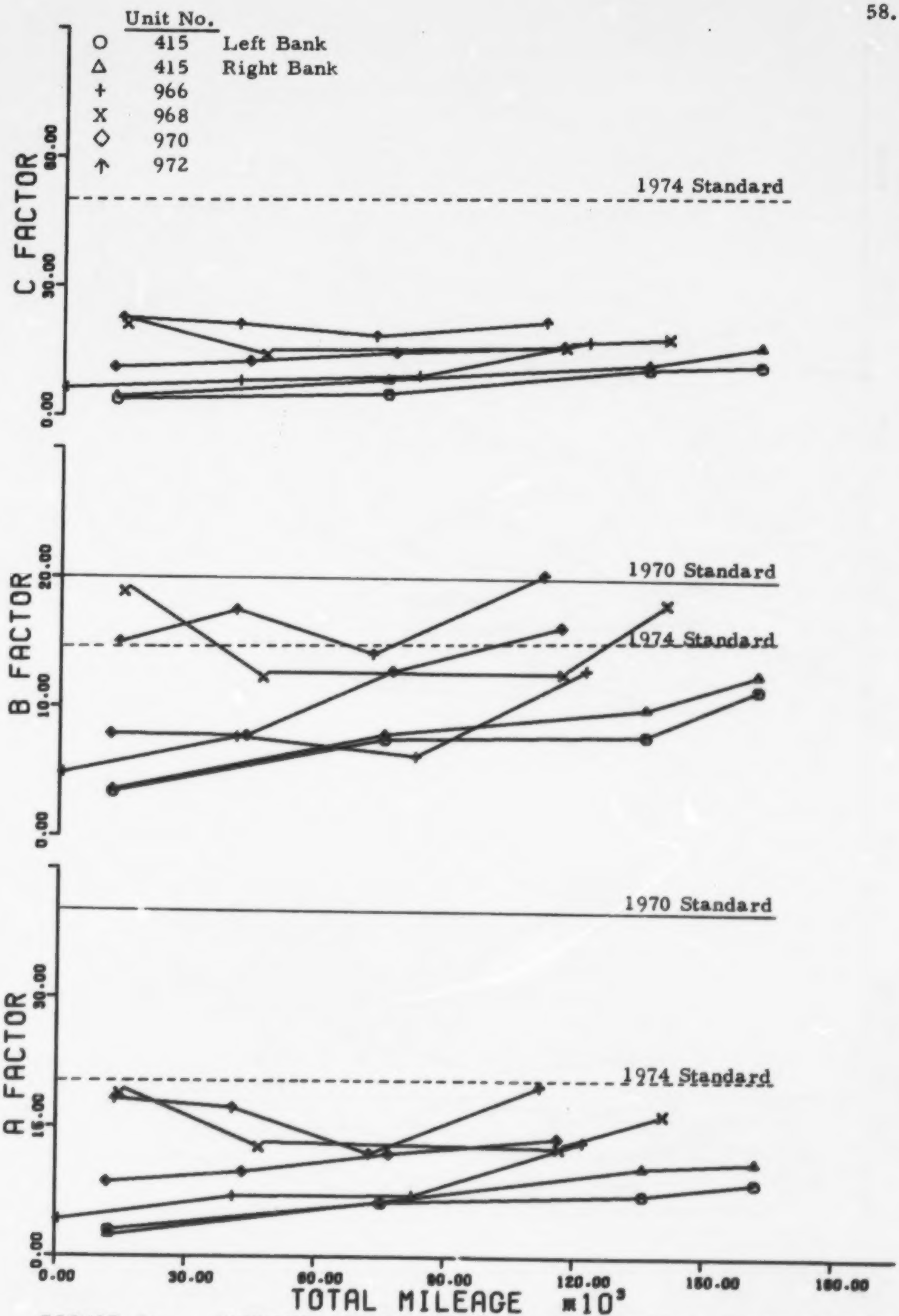


FIGURE 31. CUMMINS V-903 ENGINES IN INTERCITY TRUCK-TRACTOR

other three, plotted on Figure 32, show quite close lugdown "b" Factors all typically less than 10 percent. The increase in "b" smoke with time was similar to the other intercity tractors discussed so far.

The accel "a" factor is of much greater importance with this turbocharged group of engines. The variability between vehicles would be fairly low except for unit 458 which had relatively high "a" and correspondingly "c" peak factors. Even so, the 1970 "a" limit of 40 percent smoke was not exceeded even by unit 458. The 1974 limits of "a" 20 percent and "c" 50 percent opacity may be of future importance depending on whether this engine is fueled at its maximum rate and is otherwise unchanged. The "a" factors did not seem to deteriorate (increase) in a consistent way for this group, making judgements about the effect of mileage difficult to make.

7. Mack ENDT 675 Engines in Intercity Truck-Tractor

Figure 33 shows the effect of mileage on the two tractors which comprised this group. Both seemed to follow the same general trend of increasing smoke with mileage of about 5 percent opacity ("b") and 10 percent ("a") in 100,000 miles. This "b" Factor deterioration is quite similar to the other line-haul engines discussed so far.

The "a" Factors are significant in that for the most part they are near the 1970 limit of 40 percent. To reach this limit, an engine must produce high smoke during the transient portions of the test that is much higher than the 40 percent limit. The "c" peak factors are over the 1974 limit of 50 percent.

One concern over these two trucks and their data was the high mileage at the start of the test making the final 2 inspections well beyond 100,000 odometer miles. This does not nullify the results of the first two inspections which clearly indicate the smoke performance of two of this popular engine in line-haul intercity operation.

8. Mack ENDT 675 Engines in Commercial Garbage Trucks

This group of five trucks exhibited the greatest increase in "a" and "b" smoke of any group in the surveillance fleet. These engines, identical to those in the intercity truck-tractors were subjected to a possibly much more severe type operation, at least where smoke is concerned. The continual accel-decel and minimal maintenance given this group of vehicles during the two year surveillance period could account for the gross difference in deterioration rate between the two 675's in intercity and these five 675's in intracity usage.

According to Figure 34, the five units had about the same "a"

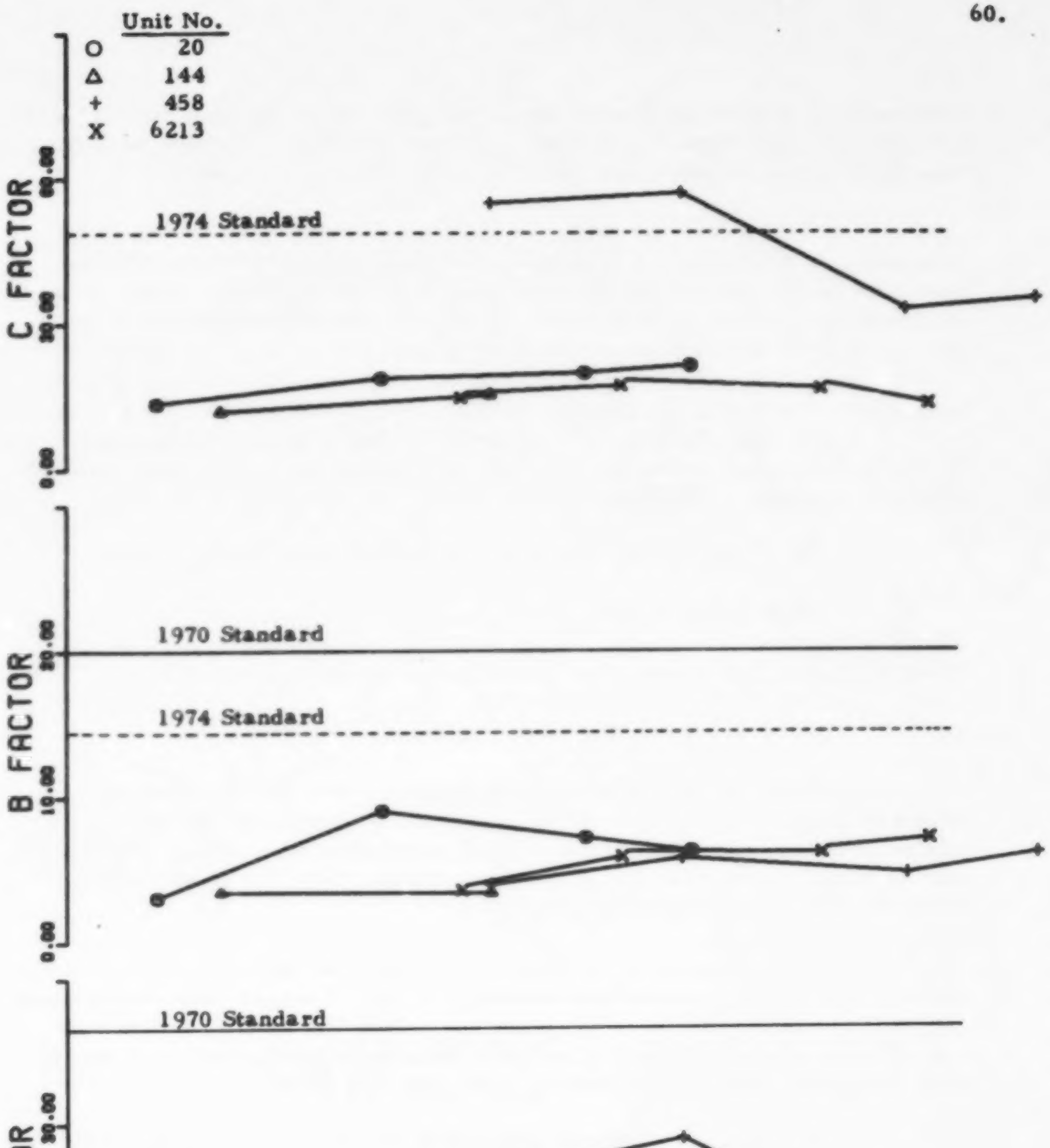


FIGURE 32. CUMMINS NTC-335 ENGINES IN INTERCITY TRUCK-TRACTOR

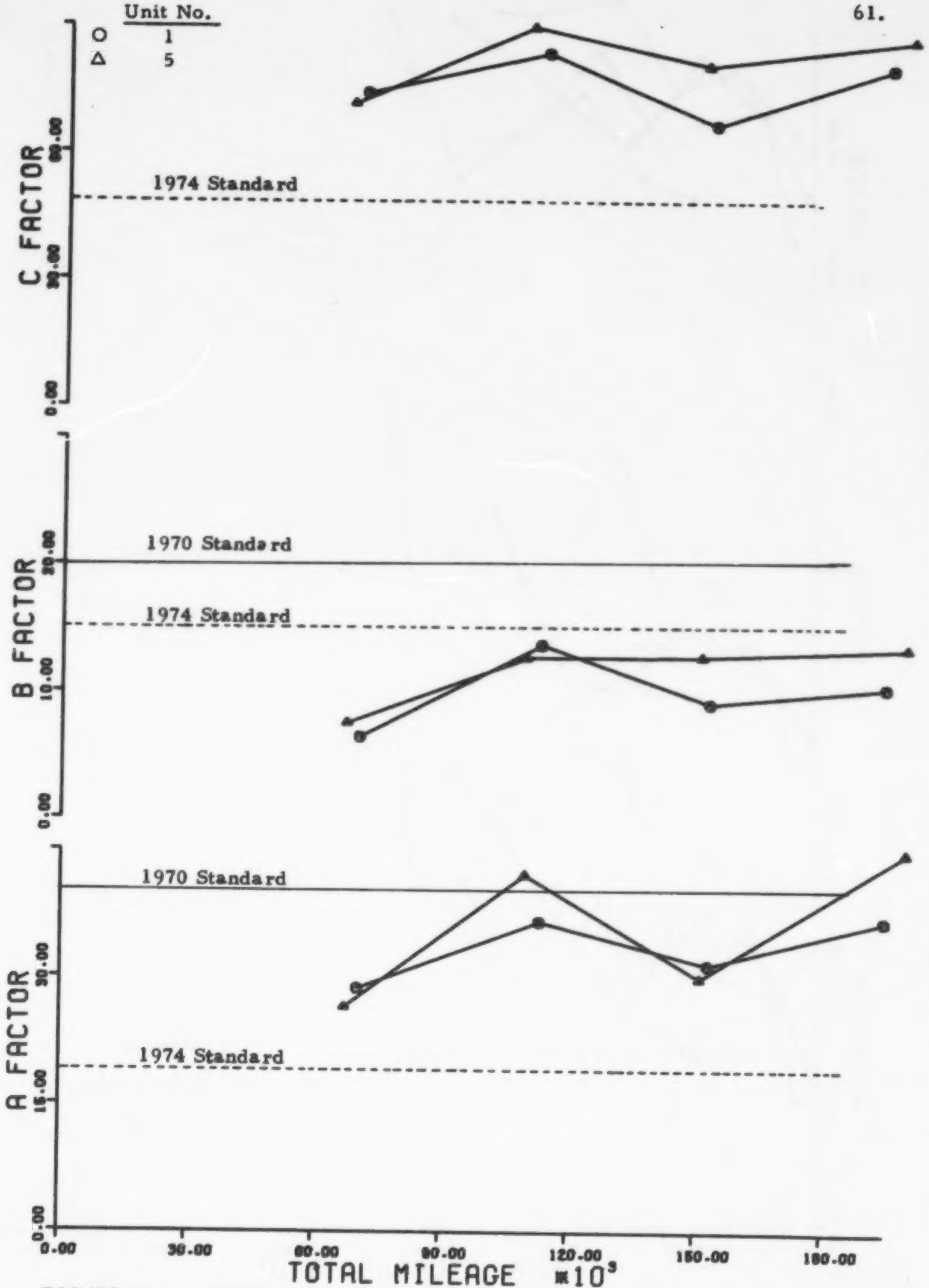


FIGURE 33. MACK ENDT 675 ENGINES IN INTERCITY TRUCK-TRACTORS

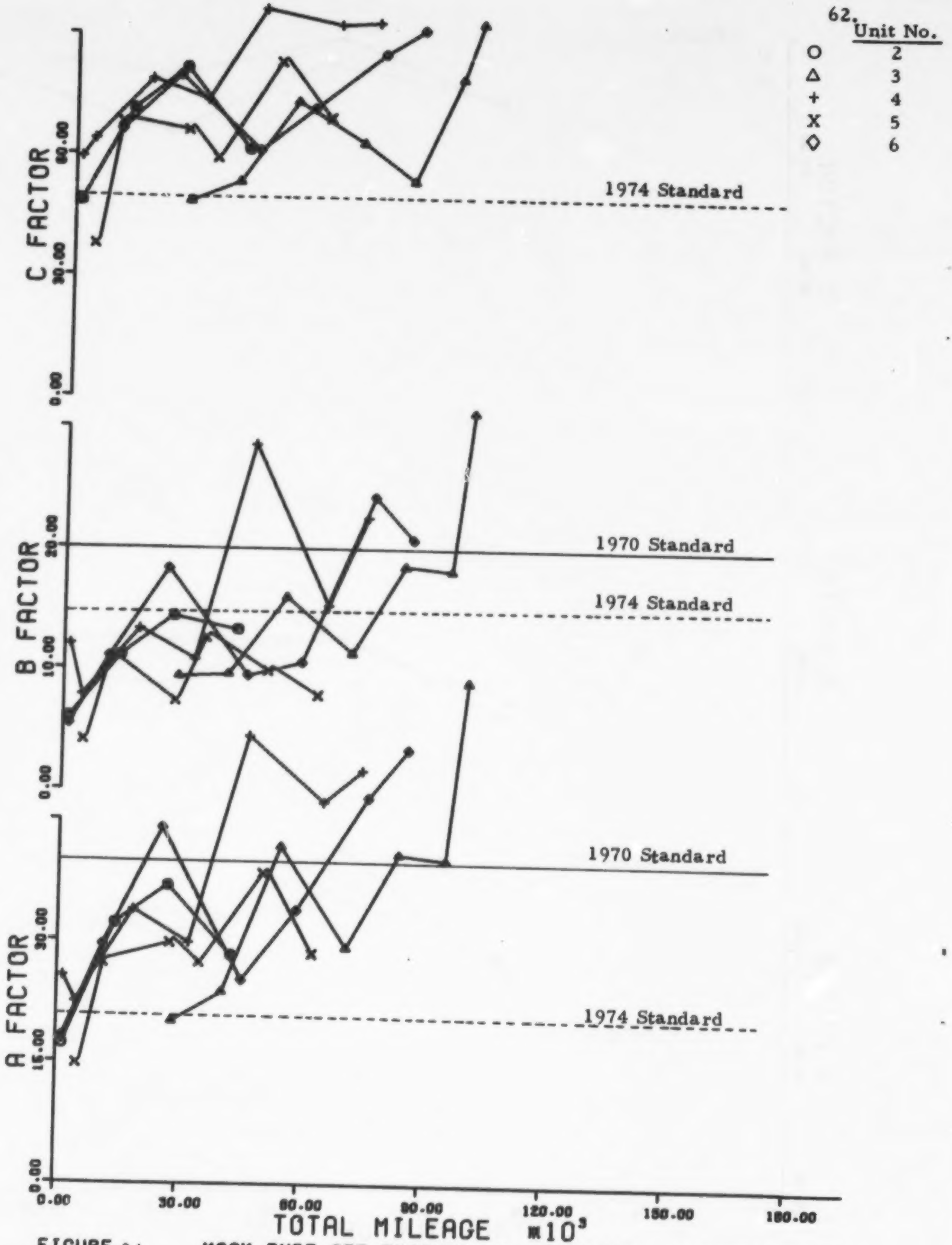


FIGURE 34. MACK ENDT 675 ENGINES IN COMMERCIAL GARBAGE TRUCKS

and "b" levels at the second inspection as the two tractors had at their first inspection. Then, because of the greater rate of deterioration, the five garbage trucks greatly increased in their "a" and "b" factors. Greater ranges of variability from truck to truck found with increased mileage are also evident in Figure 34. Both the greater deterioration rate and variability are of interest and for which there is no obvious explanation other than type of service and level of maintenance performed.

The latter should not be of major concern, however, since the trucks were below or right at 100,000 miles whereas the two 675's in tractors were in the 60,000 to 180,000 mile odometer range. Possibly the general rule of injector repair and major tune-up at 100,000 to 125,000 miles cannot apply to engines, even line-haul quality engines, in the apparently quite severe commercial garbage truck service.

The 1000 hour durability test used in certification is intended to pass as much fuel through the engine as possible in the shortest time. As a result, the engine is intentionally run at or very close to maximum rated speed and power output with no transient operation except during the smoke test and when stopping or starting the engine every 125 hours or other times for maintenance etc. Just how well the durability test predicts the smoke performance of a given engine in one or more types of service in the field has not been determined specifically.

One objective of this project was to provide field data for further consideration by EPA with regard to the efficacy of the 1000 hour durability test. As a point of interest, it may be informative to consider the smoke results obtained during this project versus those provided EPA by the manufacturer during the certification step. This item, beyond the scope of this project, could be done by computer correlation methods given the "a", "b" and "c" certification factors for the 1000 hour durability test engine.

9. Mack ENDT 673B Engines in Intracity Truck-Tractors

These two tractors reached only about 33,000 miles after two years of operation resulting in the very narrow curves of closely spaced data points of Figure 35. It is difficult to make comments on the effect of odometer mileage. The "a" Factors for both trucks increased for the first year and then became constant. The "b" Factors were fairly consistent for both trucks for the first year in their increase in smoke. Except for the final inspection "b" factor for unit 60122, the trend for both was to decrease some during the final year.

The near doubling of the "a" factor, over 10 percent opacity increase in two years makes this deterioration of interest since this is the smoke factor most evident from turbocharged engines in intracity

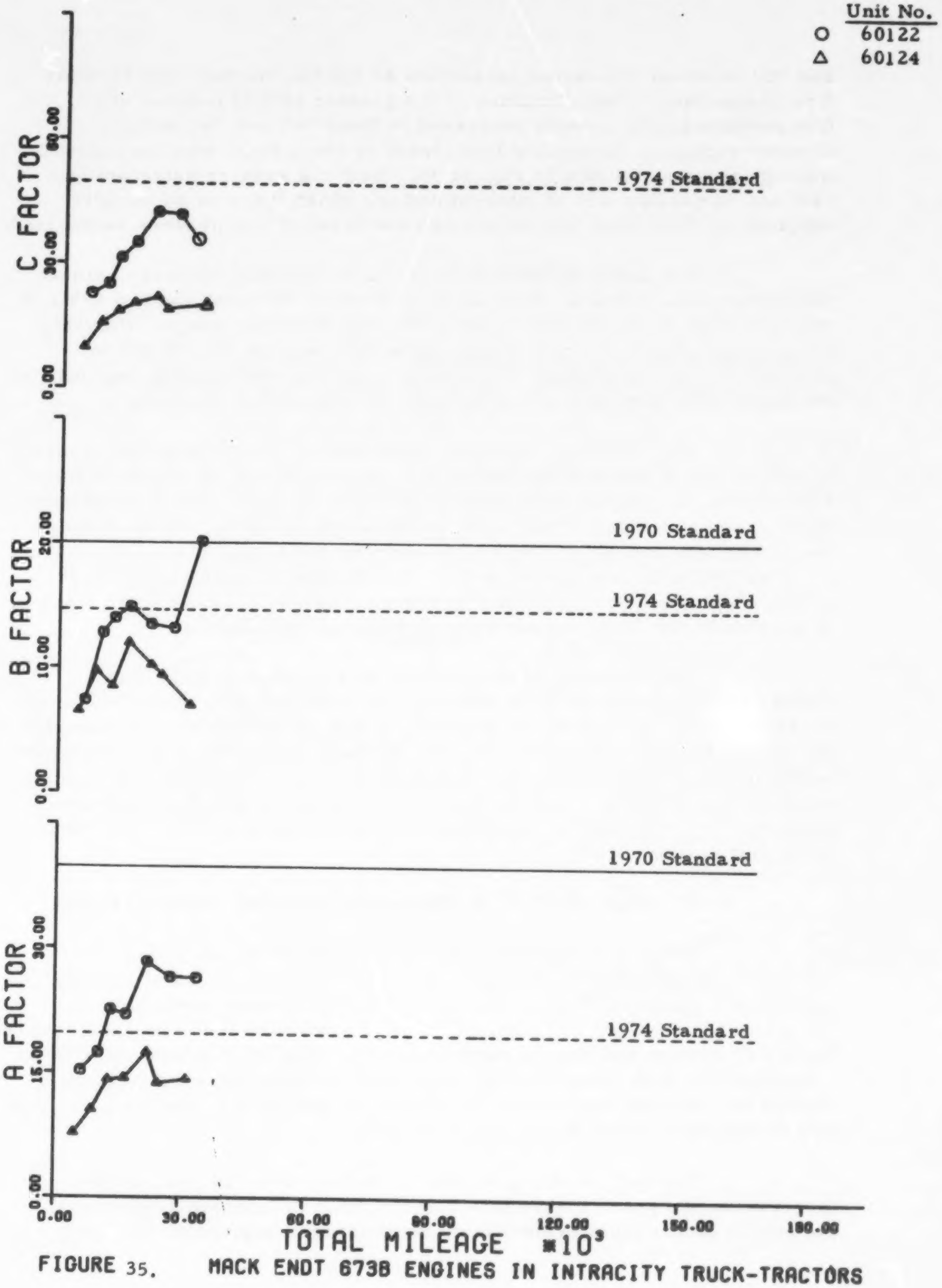


FIGURE 35. MACK ENDT 673B ENGINES IN INTRACITY TRUCK-TRACTORS

operation where a fair amount of acceleration in traffic situations occurs. From the trends of these two trucks, combined with the smoke performance of the five garbage trucks, it appears that total mileage may not be the major factor in predicting exhaust smoke, but how those miles were accumulated.

10. Caterpillar Mid-range 1145 Engines in Intracity Trucks

As with the last category, this and the remaining groups of mid-range engine powered vehicles all achieved relatively low mileage resulting in narrow or compressed curve widths. Of the five trucks graphed by computer on Figure 36, unit 519 accumulated mileage at double the rate of the other four. Although the mileage was low, the type of city delivery service may be termed severe.

An extremely wide variability in results from truck to truck and from inspection to inspection may be noted from the Figure 36 display. The unmistakable trend is toward higher "a" and "b" Factors with mileage. The rate of increase, deleting the last 30,000 miles of unit 519, was toward almost doubling the "b" factor which was the most severely affected factor. In so doing, a number of trucks and inspections produced "b" Factors substantially in excess of the 1970 limit of 20 percent opacity. The jagged appearance of the "b" factor graphs is not explainable by maintenance performed or obvious engine malfunction. There is much more to be investigated before a clear reason for the smoke behavior of this engine - vehicle group is available.

The "a" factors were generally higher than the "b" due mainly to this naturally aspirated engine acting somewhat like a turbocharged during the first accel. A momentary smoke puff was recorded that had some influence on the "a" Factor.

11. Caterpillar Mid-Range 1150 Engines in Intracity Truck-Tractors

This group of five tractors show an overall group increase of over double "b" Factor after about 34,000 miles per Figure 37. Even though the total mileage is termed moderate even for intracity operation, the "b" smoke increase may be termed significant. Involved in general freight delivery in and around San Antonio, these tractors were all maintained and no reason for the increase in smoke is evident.

The Cat 1150 engine is quite similar to the Cat 1145 previously described and the same comments relative to the "a" Factor made then apply here. The "a" Factor level and behavior with mileage was almost identical. The similarity in "b" Factors, between the 1145 and 1150 engines, were about the same in nominal or average level and in rate of

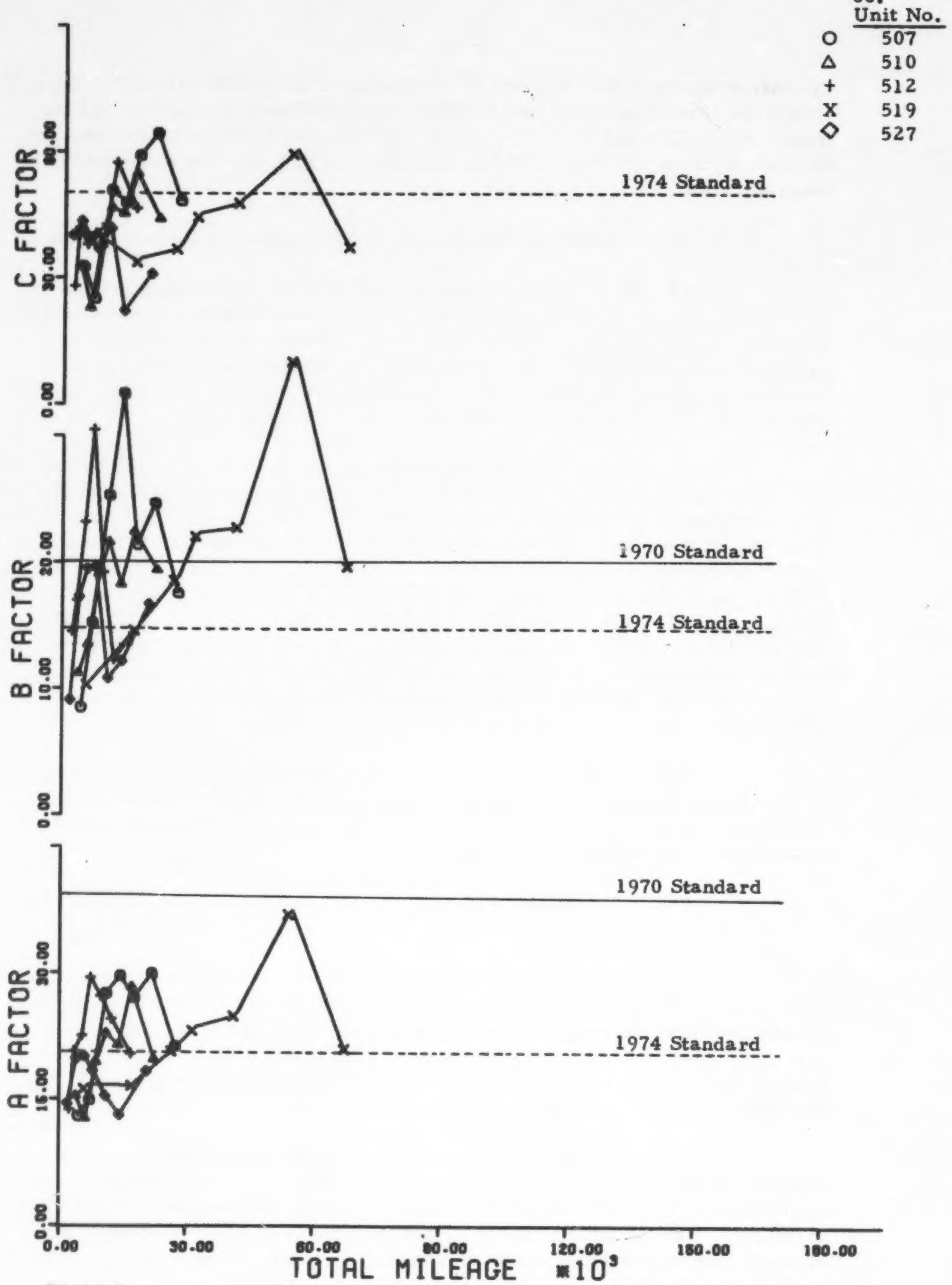


FIGURE 36. CATERPILLAR MIDRANGE 1145 IN INTRACITY TRUCKS

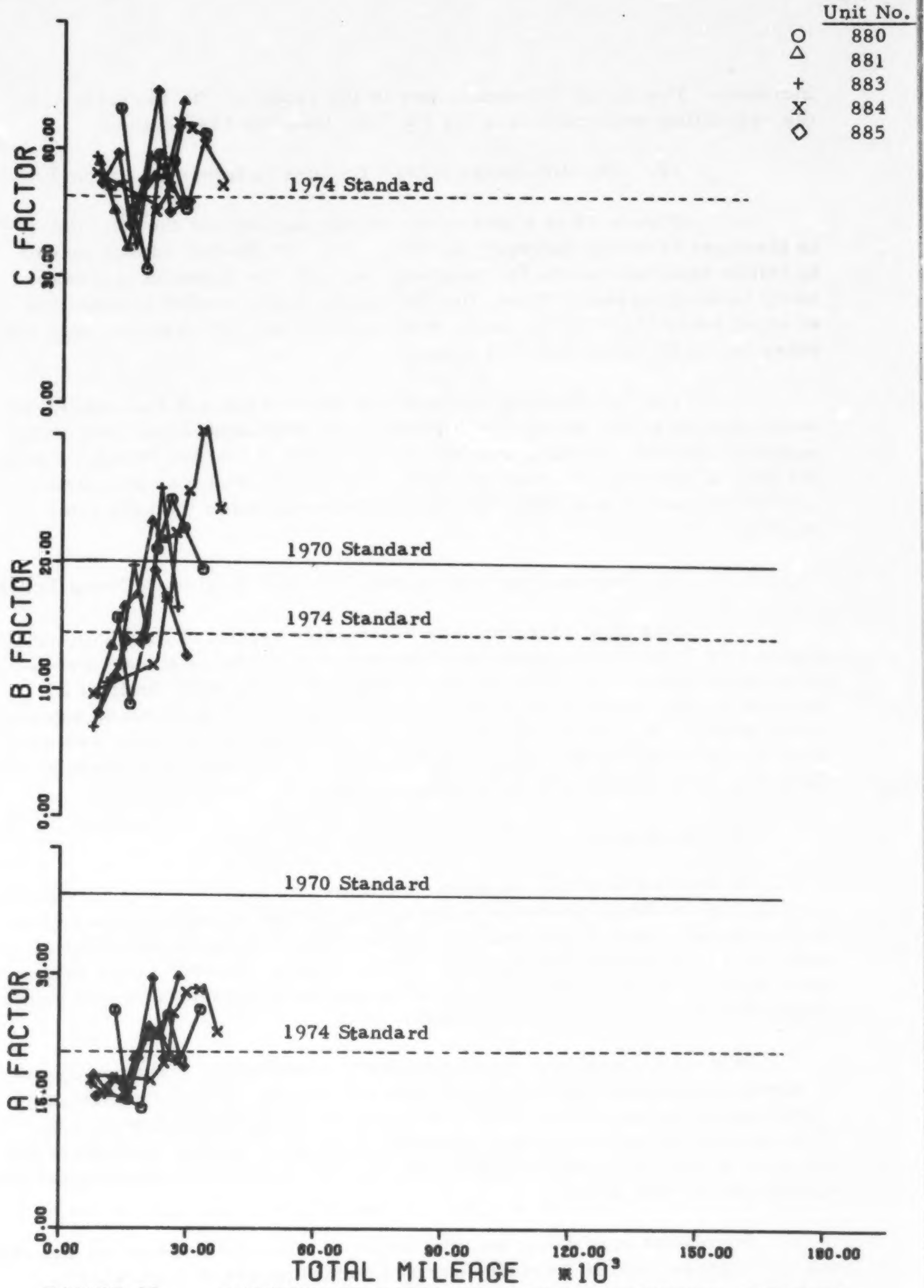


FIGURE 37. CATERPILLAR MIDRANGE 1150 IN INTRACITY TRACTORS

increase. The major difference was in the range of "b" Factors, i.e., the variability was much less for the 1150 than the 1145 engine.

12. GM Mid-Range DH478 Engines in Intracity Truck-Tractors

Figure 38 is a plot of the smoke factors for the four units in identical beverage delivery service. The "b" Factor curves tended to follow separate trends for each engine, with the common increase early in the program. Then, the "b" smoke levels tended to stabilize at about twice their initial level, with unit 137 and 133 distinct from the other two (137 higher and 133 lower).

The "a" Factors followed the same trend and had nearly the same opacity levels as the "b" lugdown. As with most other mid-range engines, the total mileage was low,on the order of 30,000 miles. Again, the type of service, the way the miles are acculated may be a much greater influence on smoke behavior and deterioration than the total mileage.

13. International Harvester DV-550B Engine in Dump Truck

This final category was a naturally aspirated line-haul quality engine in a dump truck operated intracity. Its smoke is shown versus mileage in Figure 39. The "b" factor was above the 1970 limit of 20 percent opacity about half the two years of test with a difficult to explain curve shape. The maintenance records reveal no maintenance was performed before the sixth round, but the "a" and "b" factors indicate something happened relative to the previous tests.

C. Summary

In summary of this section, the line-haul quality heavy duty engines used in high mileage intercity trucking overall had smoke increases that were nominal, about 5 percent "b" for naturally aspirated and about 10 percent "a" for turbocharged engines. Some engines showed higher values and some less. These trends were found by analysis of results on a periodic inspection basis as well with mileage.

Mid-range engines, those primarily intended for intracity operation in direct competition with gasoline powered trucks, generally produced significantly higher smoke after two years of operation than when new. The lugdown smoke from these naturally aspirated engines was generally the most greatly affected factor, though the "a" factor also experienced similar deterioration with time.

Somewhat surprising was the affect of time and mileage on line-haul quality engines used in intracity service, while naturally aspirated

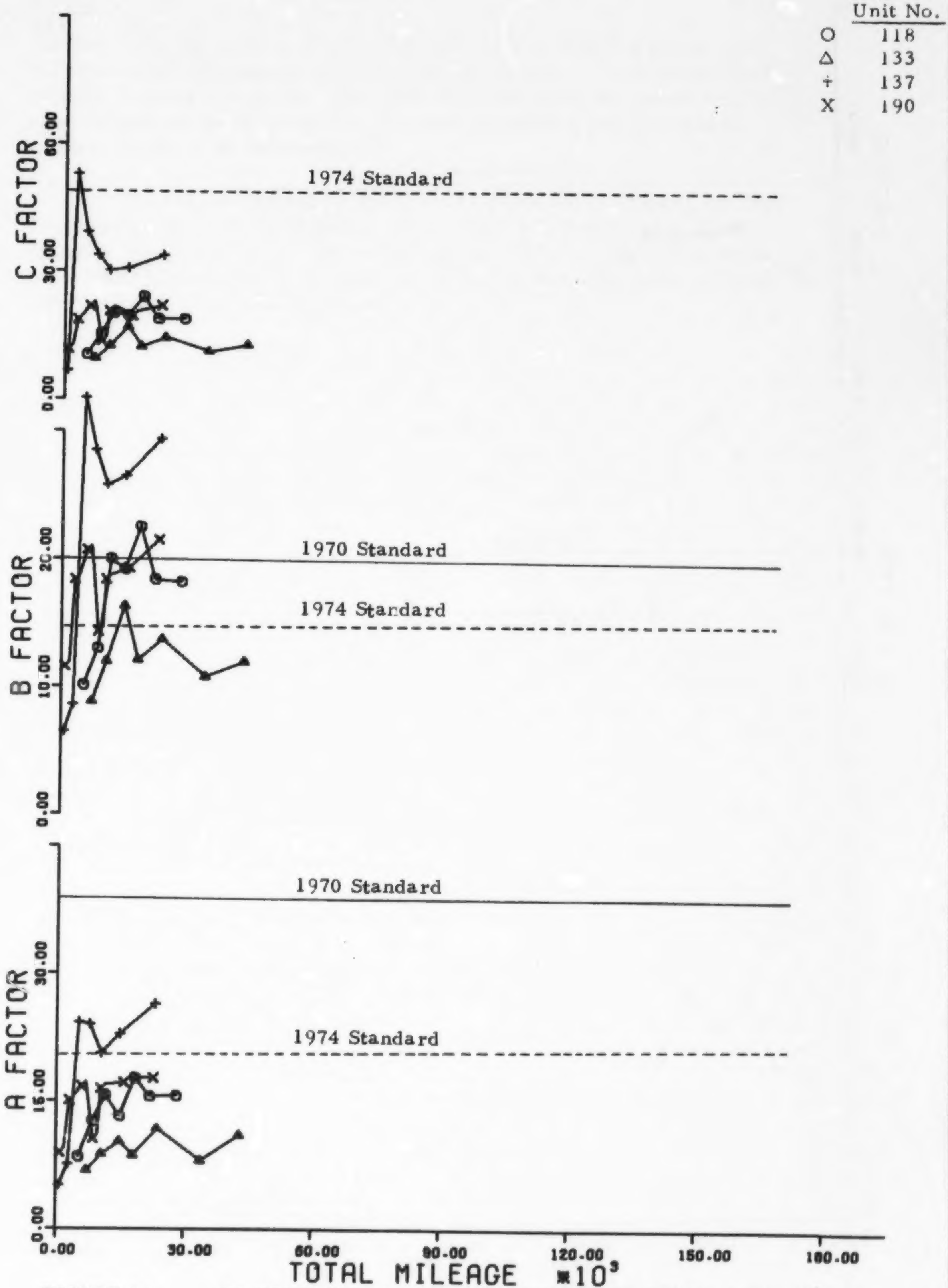


FIGURE 38. GM MIDRANGE DH-478 IN INTRACITY TRUCK-TRACTORS

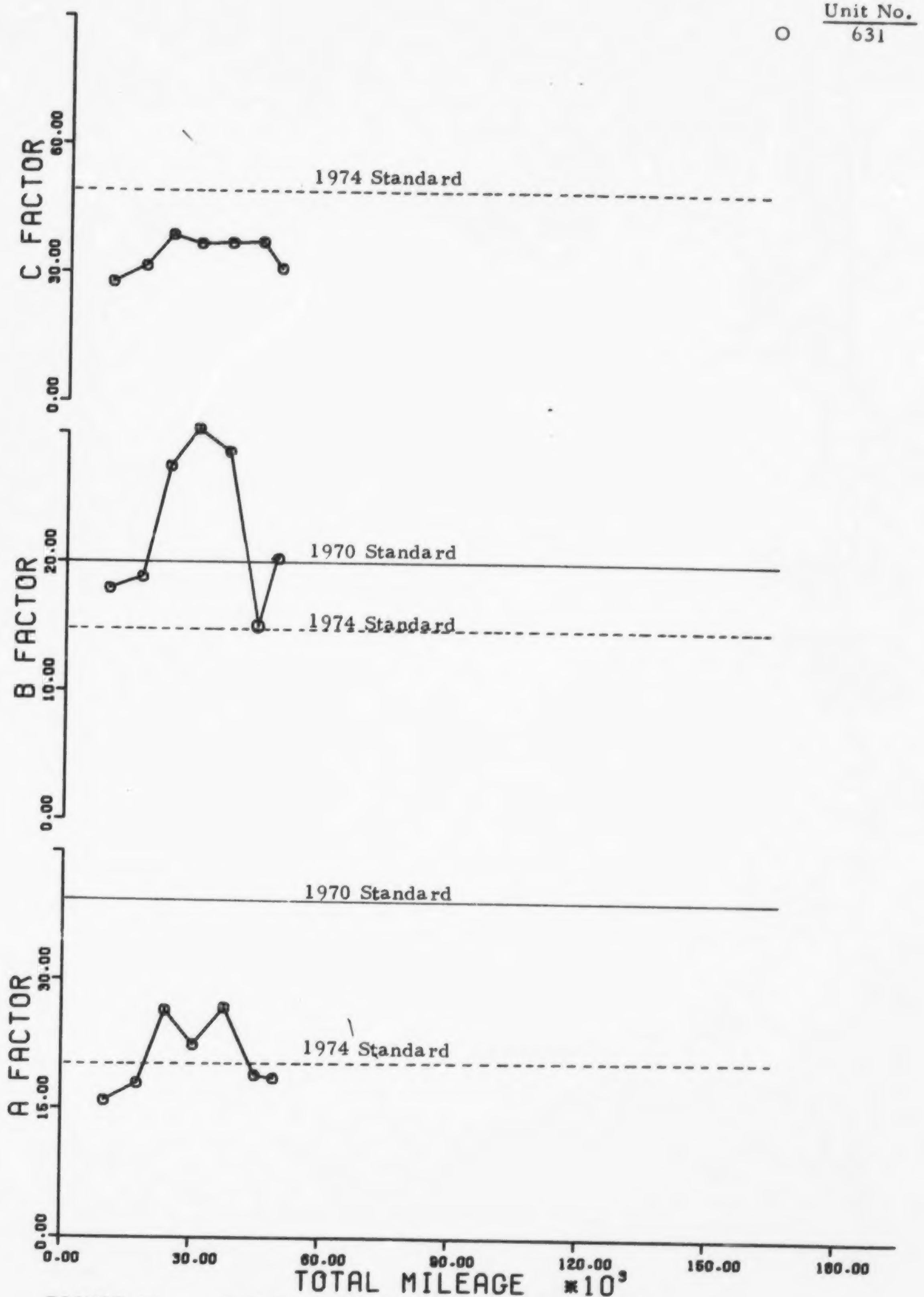


FIGURE 39. IHC DV 550B ENGINE IN DUMP TRUCK

engines hold-up well in the highly maintained city bus fleet, five turbocharged engines in commercial garbage trucks deteriorated rapidly and significantly. Another turbocharged line-haul engine used in low mileage intracity operation likewise had increased smoke, more than anticipated.

The major finding is that trucks powered by diesel engines do range in their rate of deterioration and all deteriorate some. It appears that, all other factors the same, the way the miles are accumulated may be as or even more important that total mileage on visible exhaust smoke behavior.

V. STATISTICAL ANALYSIS OF SMOKE TEST DATA

In addition to the brief statistical analysis performed on the various groups of data in the previous section, the smoke test results have been further analyzed in two ways.

A. Statistical Analysis by Inspection Period

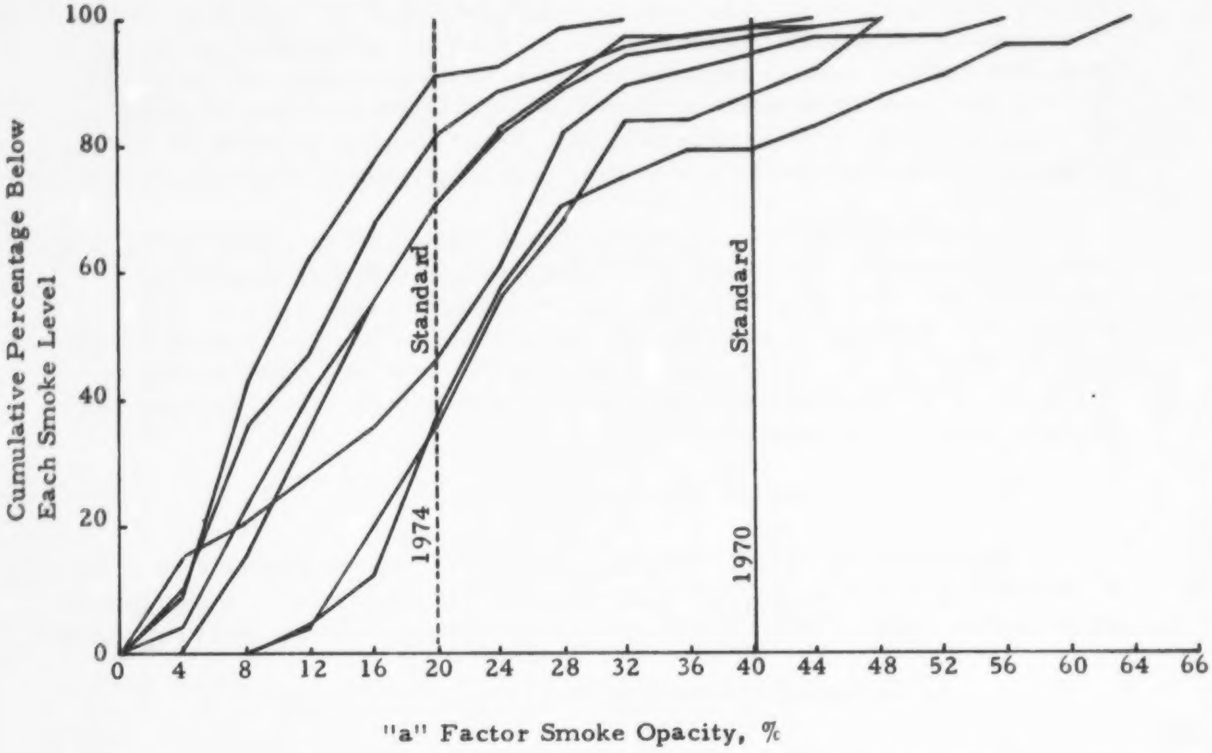
The "a" and "b" Factors for the entire fleet were analyzed on a test-by-test basis. This analysis was straightforward, but thorough; the statistical quantities obtained were the range, mean value, standard deviation, coefficient of variation and the first, second, and third quartiles. The relative frequency distribution and relative cumulative frequency distribution of the "a" and "b" Factors for each test were also obtained and are presented in both tabular and graphical form in Appendix E.

Since the primary objective of this project was to determine how the smoke output from these engines changed during the test period, it is particularly informative to compare the analysis for each test round. The statistical quantities included in the Appendix C tables discussed in the previous section, may be referred to in order to determine how the data for a particular group of engines changed over the test period.

Figure 40 indicates the relative cumulative frequency distribution of both "a" (top graph) and "b" (lower graph) smoke factors. Figure 40 summarizes on a single page all the smoke inspection statistics listed on Tables E-1 through E-7 and shown in detail in Figures E-1 through E-28. Two points may be made about the two year test from the Figure 40 graphs.

One way to assess the behavior of the fleet with time (or mileage) **may** be by the overplot of each round's results. Note that for a given cumulative percentage, the corresponding "a" and "b" Factors increased. For example, for a cumulative percentage of 50, the initial or round 1 smoke was 9 percent, while for round 2, the smoke was 12 , round 3 14 percent and so forth until round 7, the percent opacity was 23. This means that at each subsequent inspection, the "a" smoke discharge increased for a given cumulative frequency. Much the same result may be noted for the "b" Factors for the 50 percentage level. Much the same analysis may be made at any desired cumulative frequency level by reading horizontally to the desired inspection round plot and then vertically down to the corresponding smoke factor percent opacity.

The result of such analyses indicated that in general, the "a" and "b" smoke factors of the fleet were deteriorating with time. It must be kept in mind, when viewing the Figure 40 plots, that most of the intercity operated vehicles completed the test by the fourth round, a few remaining



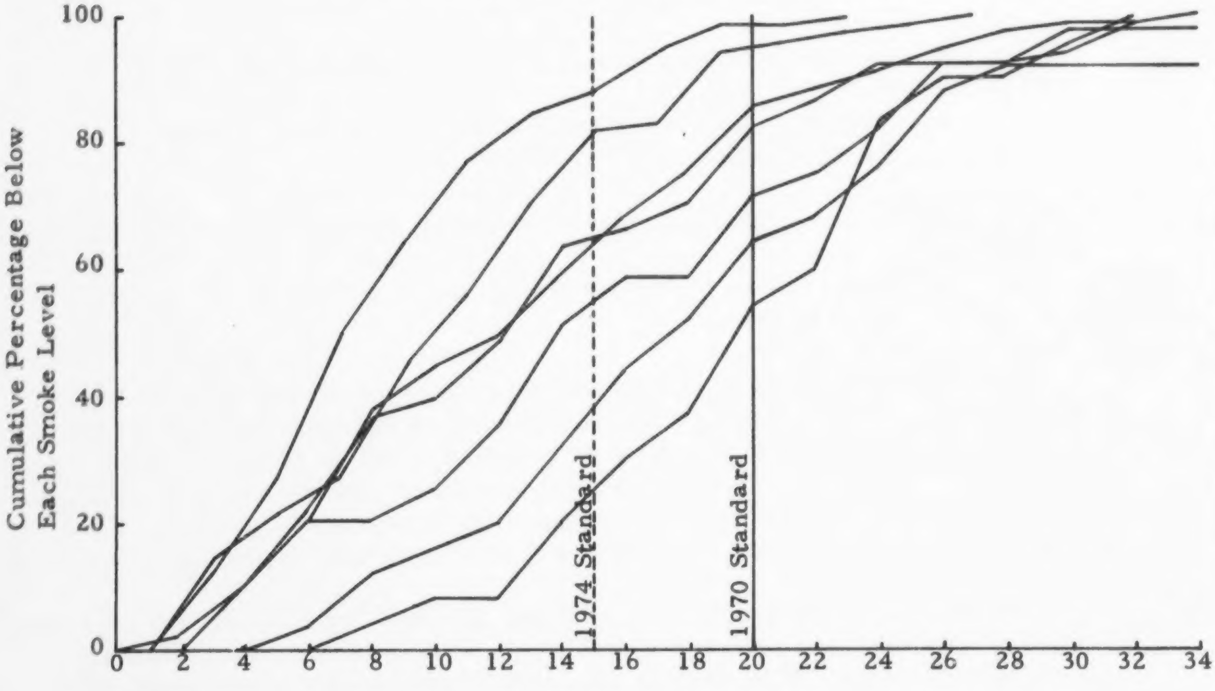


FIGURE 40. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION FEDERAL SMOKE TEST "a" AND "b" FACTORS

through the fifth round. The vehicles that continued the entire two years were mostly mid-range engines involved in intracity trucking and a few line-haul quality engines engaged in intracity, low mileage service. Thus, the last few inspection periods include a part of the original fleet and do not represent nearly the sales weighted diesel truck population as did the original fleet as operated for the first four inspections (first year).

Another way to examine the results graphed on Figure 40 is to note the cumulative frequency percentage as a function of a specific opacity level. The graphs permit one to ascertain for, say the 1970 Federal "a" limit of 40 percent, the percentage of the fleet that was less than the limit at the initial, one of the interim or at the final smoke inspection. For example, consider the "b" factor data relative to the 1970 Federal limit of 20 percent opacity.

B. Effect of Engine and Service Factors

The other statistical analysis performed was an analysis of variance to see if engine and service factors had an effect that might be considered statistically valid. The analysis involved the most obvious factors such as

1. Engine Make and Model (11)
2. Two Stroke and Four Stroke Cycle Engines (2)
3. Naturally Aspirated and Turbocharged Engines (2)
4. Naturally Aspirated and Turbocharged Four Stroke Cycle Engines (2)
5. Intracity and Intercity Operated Engines (2)
6. Midrange and Line-Haul Engines in Intracity Service (2)

The numbers in parentheses indicate how many categories were in each factor. The 11 engine make and model categories were discussed in detail in Section IV of this report with listing of all smoke test data included in Appendix C. Table 7 is a tabulation of the average "a" and "b" Factors for the other five pairings by inspection round. The differences shown are relative to the fleet averages also shown on Table 7.

As cautioned earlier in this section, the last few inspections represented less and less of the original fleet as more and more vehicles reach 100,000 miles. The results on Table 7 must therefore be used with caution round to round, although for a given round there is no problem. The fleet began to lose its inherent normal data distribution after the fourth and more after the fifth round with only part of the intracity vehicles

TABLE 7. AVERAGE "a" AND "b" FACTORS FOR VARIOUS ENGINE AND SERVICE GROUPS

Test No.	Avg. "a" Factor	Avg. "b" Factor	Avg. "a" Factor	Avg. "b" Factor	Difference*, Δ"a"	Difference*, Δ"b"	Avg. "a" Factor	Avg. "b" Factor	Difference*, Δ"a"	Difference*, Δ"b"
	Fleet		Two-Stroke Cycle Engines				Four-Stroke Cycle Engines			
1	10.9	7.9	6.0	3.9	-4.9	-4.0	13.7	10.0	+2.8	+2.1
2	13.6	10.1	8.5	5.3	-5.1	-4.8	16.7	12.9	+3.1	+2.8
3	16.0	12.5	10.3	6.4	-5.7	-6.1	19.4	16.2	+3.4	+3.7
4	16.2	13.0	9.9	5.6	-6.3	-7.4	19.9	17.3	+3.7	+4.3
5	19.9	15.3	10.9	8.1	-9.0	-7.2	25.5	19.8	+5.6	+4.5
6	24.4	17.8	19.1	10.7	-5.3	-7.1	25.4	19.2	+1.0	+1.4
7	27.4	18.9	35.8	16.8	+8.4	-2.1	26.2	19.5	-1.2	+0.6
			Naturally Aspirated Engines				Turbocharged Engines			
1			9.5	8.1	-1.4	+0.2	17.1	6.1	+6.2	-1.8
2			11.3	10.3	-2.3	+0.2	23.7	9.5	+10.1	-0.6
3			13.6	12.8	-2.4	+0.3	27.4	11.0	+11.4	-1.5
4			14.3	13.4	-1.9	+0.4	25.0	10.7	+8.8	-2.3
5			22.1	21.4	+2.2	+6.1	35.8	15.2	+15.9	-0.1
6			21.3	18.8	-3.1	+1.0	34.0	14.7	+9.6	-3.1
7			20.5	18.9	-6.9	0.0	41.6	20.4	+14.2	+1.5
			Naturally Aspirated 4-Stroke Engines				Turbocharged 4-Stroke Engines			
1			12.3	11.6	+1.4	+3.7	17.1	6.1	+6.2	-1.8
2			13.7	14.4	+0.1	+4.3	23.7	9.5	+10.1	-0.6
3			16.4	18.2	+0.4	+5.7	27.4	11.0	+11.4	-1.5
4			17.9	19.8	+1.7	+6.8	25.0	10.7	+8.8	-2.3
5			22.1	21.4	+2.2	+6.1	35.8	15.2	+15.9	-0.1
6			21.9	21.0	-2.5	+3.2	34.0	14.7	+9.6	-3.1
7			20.5	18.9	-6.9	0.0	41.6	20.4	+14.2	+1.5
			Intracity Engines				Intercity Engines			
1			11.9	7.6	+1.0	-0.3	9.7	7.8	-1.2	-0.1
2			15.1	10.5	+1.5	+0.4	11.9	9.7	-1.7	-0.4
3			18.5	13.6	+2.5	+1.1	13.1	11.3	-2.9	-1.2
4			16.9	13.5	+0.7	+0.5	14.9	11.9	-1.3	-1.1
5			19.9	14.5	0.0	-0.8	19.8	25.4	-0.1	+10.1
6			24.4	17.8	-	-	-	-	-	-
7			27.4	18.9	-	-	-	-	-	-
			Midrange Engines in Intracity Service				Line-Haul Engines in Intracity Service			
1			12.7	8.3	+1.8	+0.4	11.0	6.9	+0.1	-1.0
2			16.7	12.4	+3.1	+2.3	13.4	8.5	-0.2	-1.6
3			19.6	17.2	+3.6	+4.7	17.4	9.8	+1.4	-2.7
4			19.2	17.7	+3.0	+4.7	14.6	9.2	-1.6	-3.8
5			22.4	18.5	+2.5	+3.2	17.0	10.0	-2.9	-5.3
6			21.5	19.1	-2.9	+1.3	31.9	14.7	+7.5	-3.1
7			24.0	18.4	-3.4	-0.5	37.7	20.4	+10.3	+1.5

and engines remaining for the last two inspections. These last inspections do not represent the engine population, making their comparison to earlier rounds inappropriate.

The analysis of variance results are listed on Table 8 for the six engine and service factors by inspection. Please note that the S denotes that the variable or one group is different from another variable or group at the 0.01 significance level. In other words, there is a one percent or less chance that the smoke emission factor differences seen between, say engine make are due to pure chance.

1. Engine Make and Model

Engine Group, i.e., make and model had "a" and "b" Factors that were statistically different (except "b" at sixth and seventh rounds). Thus, make and model had a reliable and consistent influence on the "a" and "b" smoke factors. Of all the groupings and pairings of engine and service variables, engine make and model was without doubt the most important. The lack of significance at the last two inspections is due to the small group of engines remaining in the fleet and their great similarity.

2. Two and Four Stroke Cycle Engines

The effect of whether an engine is designed on a two-stroke cycle or four-stroke cycle was found to also be statistically lower. This analysis of variance is considered to be a marginal test of significant effect for the last two inspections. The two-stroke engines were all of Detroit Diesel manufacture and included the 71 and 53 series non-turbocharged engines. The four stroke engines included both line-haul and mid-range naturally aspirated and turbocharged engines. It is not too surprising, in view of the data obtained, that there is a strong effect on smoke. If, however, one considers the large volume sales Detroit Diesel 71 series two-stroke and the Cummins NHC-250 four stroke engine, there is really little difference in combustion system. Both use unit injectors, and open chambers which tend to work-out other features which seem important, but really are not. One engine happens to feature low smoke at the expense of high NO_x, while the other produces the reverse.

3. Naturally Aspirated and Turbocharged Engines

Possibly a better comparison would be between naturally aspirated and turbocharged engines. As expected, the analysis of variance points up the gross differences in "a" factors, the acceleration mode where the turbocharger traditionally results in higher transient smoke discharges. Also, as expected the variety of high and low smoke tendency naturally aspirated engines and the normally low smoke turbocharged engines smoke data intermingle and sufficiently overlap to result in no statistical difference.

TABLE 8. ANALYSIS OF VARIANCE RESULTS FOR SIX ENGINE AND SERVICE FACTORS

Inspec. Round	Engine Group	2 or 4 Strokes/c	Turbochgd. or Nat. Asp.	Turbochgd. or Nat. Asp. in 4-stroke only	Intra-or Intercity	Mid. or L.H. in Intracity
			"a" Factor			
1	S(1)	S	S	NS	NS(2)	NS
2	S	S	S	S	NS	NS
3	S	S	S	S	NS	NS
4	S	S	S	S	NS	NS
5	S	S	S	S	NS	NS
6	S	NS	S	NS	-	NS
7	S	NS	S	S	-	NS
			"b" Factor			
1	S	S	NS	S	NS	NS
2	S	S	NS	S	NS	S
3	S	S	NS	S	NS	S
4	S	S	NS	S	NS	S
5	S	S	NS	NS	NS	S
6	NS	NS	NS	NS	-	NS
7	NS	NS	NS	NS	-	NS

(1) S denotes that variable is significant at .01 significance level
(2) NS denotes that variable is not significant at .01 significance level

4. Naturally Aspirated and Turbocharged Four-Stroke Cycle Engines

This is the fourth column of data on Table 8 and it is clear that this pair or split of the four stroke cycle engines does not give a consistent, statistically different, "a" or "b" smoke discharge throughout the two year test. The "a" Factors were different due to this pairing at all but the first and sixth inspection. This mostly different behavior during the transient portion of the test was expected in that this pairing is a special case of all turbocharged and naturally aspirated engines discussed in paragraph 3. Some of the mid-range engines, though four stroke naturally aspirated, responded more like turbocharged engines than the usual line-haul engine during the accel and could have accounted for the lack of difference at the sixth inspection.

The "b" Factor was statistically different on account of type of aspiration of the four stroke cycle group during the first year. This is to be expected from the usually higher smoke during the quasi-steady state lugdown from non turbocharged versus turbocharged four-stroke diesels. The lack of difference during the final year probably reflects the different composition of the fleet being mostly mid-range engines.

5. Intracity and Intercity Operated Engines

All the engines were involved in the one of the two categories by service, intercity or intracity. Although it was felt that this might be important since it apparently played heavily in the deterioration rate discussions of Section IV when analyzed on a round by round basis, it may be seen that it is not of significance. Note the delta differences on Table 7 for the intracity and intercity categories relative to the fleet average. The make-up of the two groups and their observed smoke levels were each very close to the overall fleet total. This may have been because both two and four stroke engines turbocharged and naturally aspirated were in each group.

6. Mid-Range and Line-Haul Quality Engines in Intracity Service

This and the next pair of variables were investigated from a general interest standpoint because of the findings with vehicles in the intracity type of service. This is considered to be a light to severe duty which is characterized by long idle periods, repetitive accelerations and decelerations with short term operation at near or rated speeds and loads and accumulating on the order of 20,000 to 50,000 miles per year. From the "a" Factor standpoint, it did not matter what the quality of the engine was, as no statistical significance was found. During four of the inspections - second, third, fourth and fifth, a difference in "b" Factor is indicated on Table 8. The effect is not considered of major significance because of its lack of consistancy i. e., at the first round.

The somewhat surprising point of this is that four high quality line-haul type engines, the GM 6V-71 in city buses, the Mack ENDT-673B in delivery tractor trailers, the Mack ENDT-675 in garbage pickup and the IH DV550 in a dump truck did not consistently show a consistent difference from the mid-range GM 6V-53N, GM-DH478, Cat 1145 and 1150 engines also used in the same service. Perhaps the type of operation is sufficiently severe to eliminate what differences quality might have on smoke output.

VI. RESULTS OF GASEOUS EMISSIONS TESTS

Fifty-nine of the 64 vehicles in the test fleet underwent the chassis dynamometer version of the California ARB emissions Test. This procedure was described in Section III B and Appendix E of this report. The five commercial garbage trucks could not be tested because of tire overheating problems during the test. The results in this section are grouped under two major headings, two-cycle engines and four-cycle engines. This division is a matter of convenience only, and is not meant to imply a comparison of the emissions of the two types of engines.

The data include observed brake specific quantities of HC, CO, NO_2, and HC + NO_2, and the values are the average of all tests (usually two) of each engine/vehicle. The data are principally compared to the 1974 Federal limits (same as 1973 California standards) and 1975 California standards for BSCO and BSHC + $BSNO_2$. These tests were conducted prior to the development of a Federal Test and utilized the chassis alternative of the California procedure. The results and their comparison to existing and future standards should be made from this standpoint. A simple statistical analysis, providing the average, mean and standard deviations, and coefficient of variation, has been performed on the data for each engine group, and the results presented in the tables. Another statistical analysis, which considers the fleet as a whole, appears later in this section.

A. Two-Cycle Engines

Table 9 contains the brake specific emissions data for the Detroit Diesel engines of the "71" and "53" series. The brake specific values for the five 8V engines with separate dual exhaust outlets were obtained by performing one test for each engine bank and then averaging the two sets of data. This approach is justified since the brake specific results are based on mass flow rates that can be combined and averaged. The first three sets of bars in Figures 41, 42, 43, and 44, illustrate the minimum, maxiumumk and average values of BSHC, BSCO, $BSNO_2$ and BSHC + $BSNO_2$, respectively, for the two-cycle engines.

These engines were generally characterized by low BSHC and high $BSNO_2$. (It should be noted that only NO was measured directly; the $BSNO_2$ values were obtained by multiplying BSNO values by 1.533, the ratio of the respective molecular weights.) The 8V engines had the lowest BSHC, followed in order by the 6V-71 and 6V-53 models. The 6V-71 engines generally had the lowest $BSNO_2$ and the 6V-53 the highest, with the 8V engine between these two extremes. Seven of the ten 6V-71 engines met the 1974 Federal (1973 California) limit of 16 g/bhp-hr of HC + NO_2, while none of the 6V-53 models were under this particular limit. Of the six 8V engines, only the derated version (290 hp, 60-mm^3 injectors) in the intercity bus met the 1974 Federal standard for brake specific HC + NO_2. The 1975 limit of 5 g/bhp-hr of these same contaminants was substantially lower than the current emission levels of these two-cycle engines (Figure 44). The 8V engines generally had the lowest BSCO and the 6V-71 models had the highest. The 1974 Federal (California's 1973) and the California 1975 limits

TABLE 9. BRAKE SPECIFIC EMISSIONS FOR VEHICLES POWERED BY TWO-CYCLE ENGINES

		g/bhp-hr				
No.	**Mileage**	**BSHC**	**BSCO**	**BSNO**	**BSNO$_2$**	**BSHC + BSNO$_2$**
Engine: Detroit Diesel 6V-71N (LSN 60 Injectors) **Vehicle: GM Intracity Bus**						
815	56,203	1.67	7.52	9.54	14.63	16.30
816	44,560	0.97	7.96	7.85	12.03	13.00
817	56,548	1.55	7.93	8.04	12.33	13.88
818	61,200	1.15	10.42	8.86	13.59	14.74
819	62,542	1.08	11.37	8.13	12.47	13.55
820	55,590	0.96	9.75	9.69	14.88	15.84
821	58,137	1.02	9.48	9.10	13.95	14.97
822	59,185	1.15	10.37	9.79	15.01	16.16
823	59,855	1.10	9.54	9.95	15.26	16.36
824	57,223	1.00	9.57	9.72	14.90	15.90
Average		1.17	9.39	9.07	13.91	15.07
Mean Deviation		0.18	0.95	0.68	1.04	1.04
Standard Deviation		0.25	1.24	0.80	1.23	1.24
Coefficient of Variation		0.21	0.13	0.09	0.09	0.08
Engine: Detroit Diesel 8V-71N (LSN 65 Injectors) **Vehicle: Intercity Truck-Tractor**						
104	59,990	0.89	7.99	11.08	16.99	17.88
105	62,855	0.76	6.87	10.82	16.60	17.36
106	61,485	0.76	7.02	10.16	15.58	16.34
107	48,487	0.85	6.58	9.90	15.17	16.02
405	61,050	0.86	6.98	11.98	18.36	19.22
Average		0.82	7.09	10.79	16.54	17.37
Mean Deviation		0.05	0.36	0.61	0.93	0.95
Standard Deviation		0.06	0.53	0.82	1.26	1.28
Coefficient of Variation		0.07	0.07	0.08	0.08	0.07
Engine: Detroit Diesel 8V-71N (LSN 60 Injectors) **Vehicle: Intercity Bus**						
591	59,234	0.49	7.16	4.89	7.50	7.99
Engine: Detroit Diesel 6V-53N (LSN 45 Injectors) **Vehicle: Refrigerated Van**						
3	22,754	1.48	9.48	12.10	18.55	20.03
4	20,402	1.66	7.30	10.98	16.83	18.49
8	26,664	1.86	10.02	12.87	19.73	21.59
10	23,926	1.56	8.40	11.50	17.63	19.19
16	21,069	1.64	8.58	11.64	17.84	19.48
Average		1.64	8.76	11.82	18.12	19.76
Mean Deviation		0.10	0.80	0.53	0.82	0.84
Standard Deviation		0.14	1.05	0.71	1.09	1.17
Coefficient of Variation		0.09	0.12	0.06	0.06	0.06

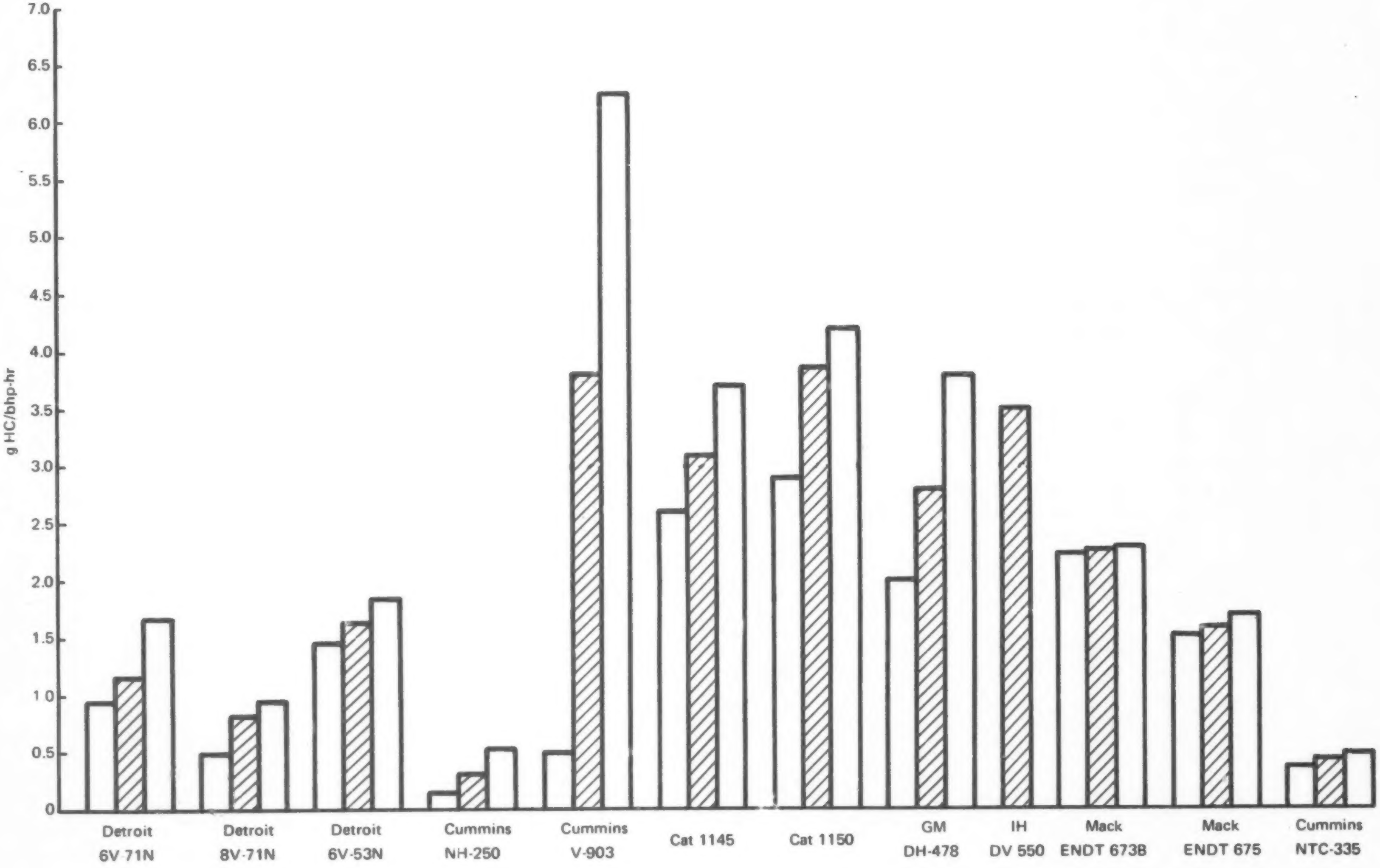


FIGURE 41. MINIMUM, MAXIMUM, AND AVERAGE BRAKE SPECIFIC HC FOR 59 HEAVY-DUTY DIESEL ENGINES (Chassis Dynamometer Alternative to California ARB Procedure)

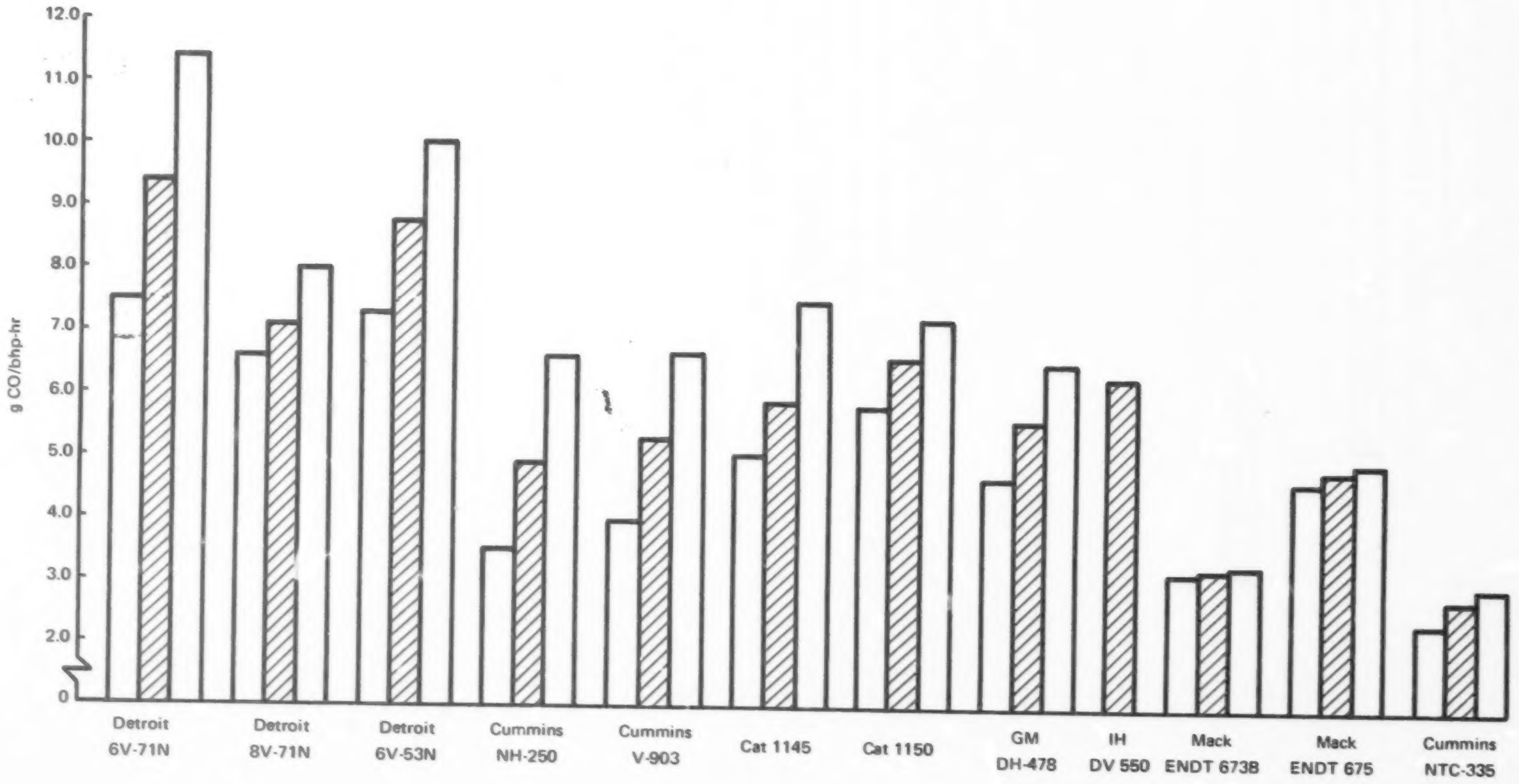


FIGURE 42. MINIMUM, MAXIMUM, AND AVERAGE BRAKE SPECIFIC CO FOR 59 HEAVY-DUTY DIESEL ENGINES
(Chassis Dynamometer Alternative to California ARB Procedure)

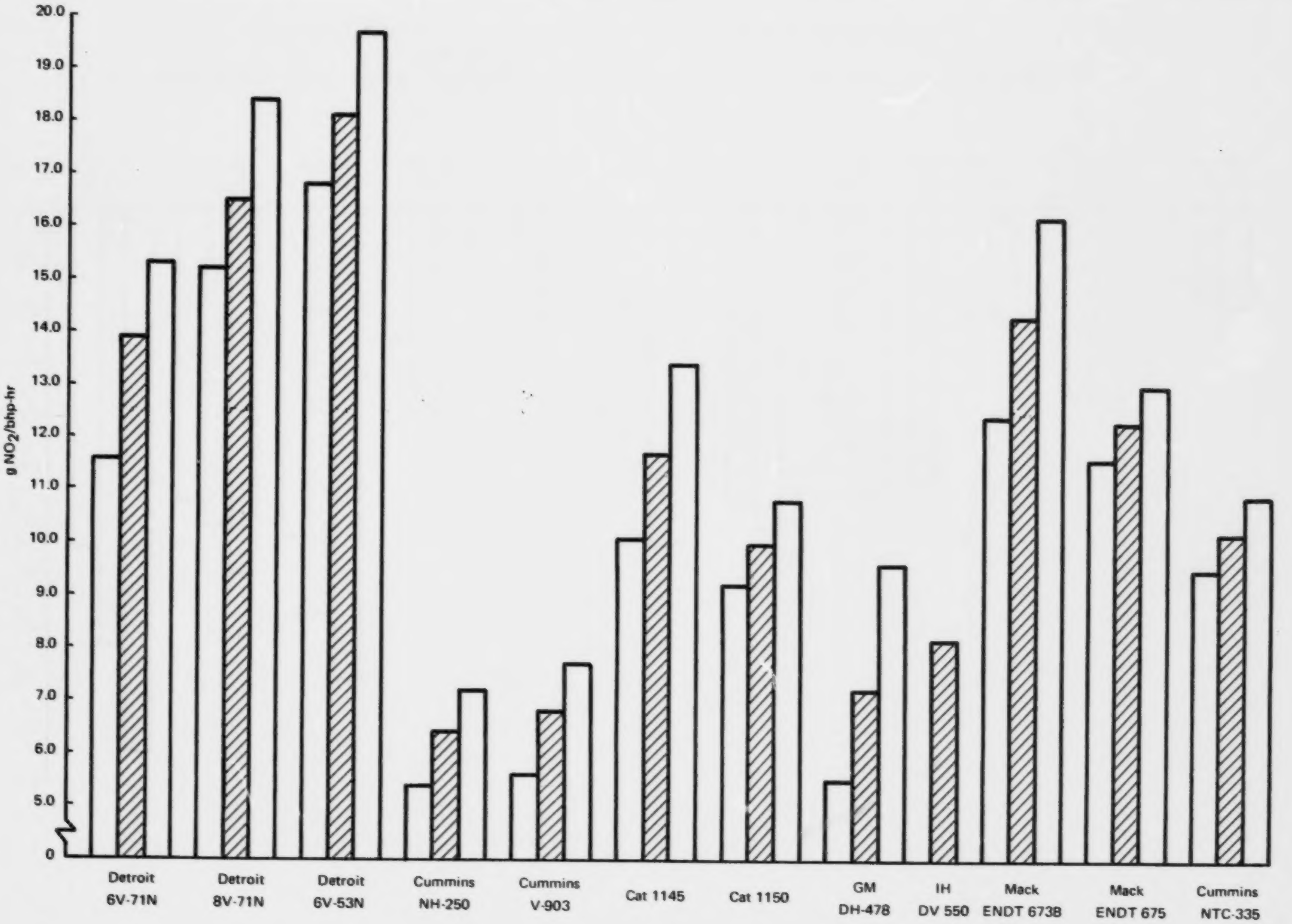


FIGURE 43. MINIMUM, MAXIMUM, AND AVERAGE BRAKE SPECIFIC NO2 FOR 59 HEAVY-DUTY DIESEL ENGINES
(Chassis Dynamometer Alternative to California ARB Procedure)

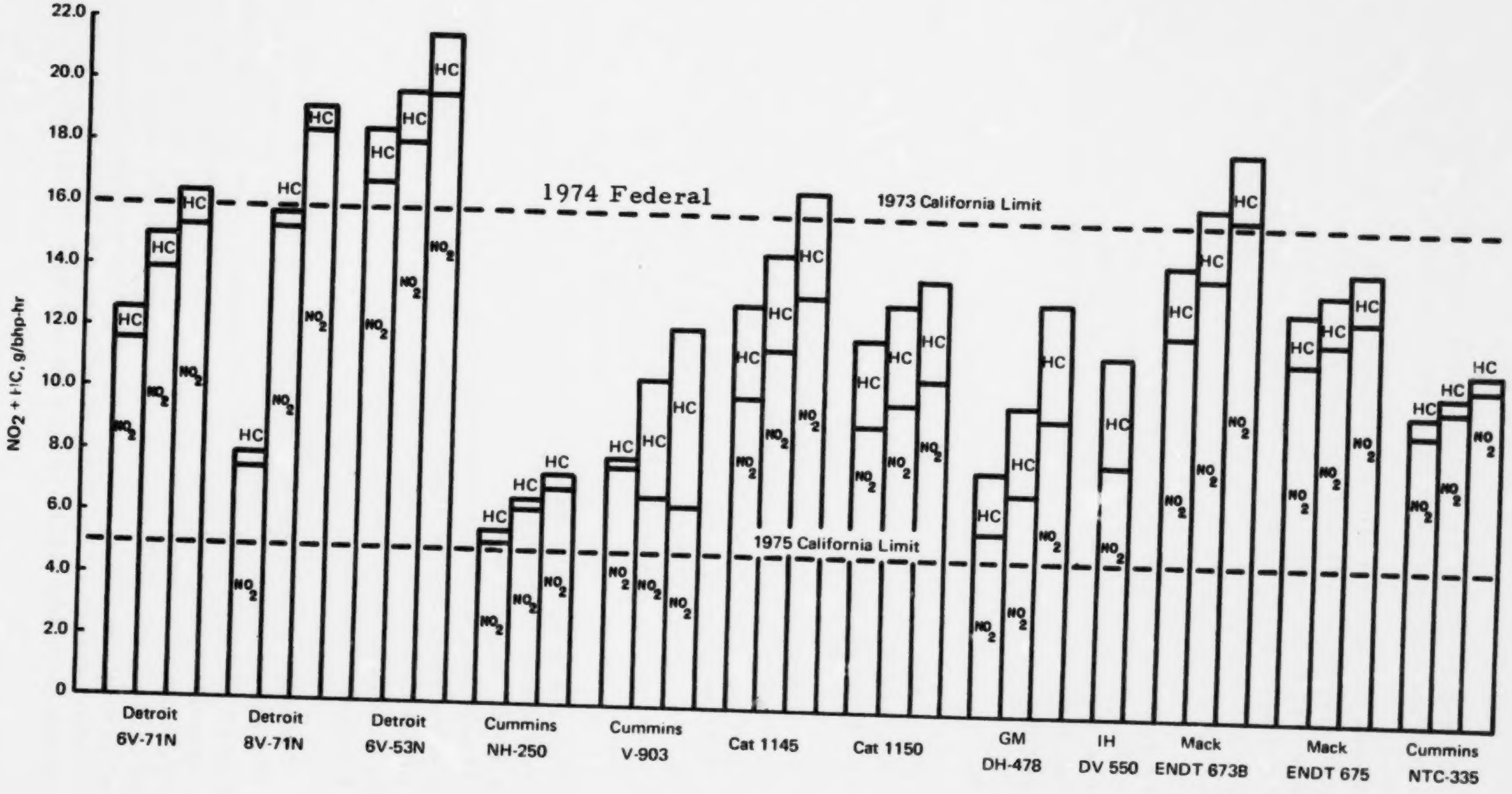


FIGURE 44. MINIMUM, MAXIMUM, AND AVERAGE BSHC + BSNO$_2$ FOR 59 HEAVY-DUTY DIESEL ENGINES
(Chassis Dynamometer Alternative to California ARB Procedure)

on CO of 40 and 25 g/bhp-hr, respectively, were based on spark-ignition gasoline engines and hence are not really applicable to diesel engines.

These two-cycle engines, although of the same basic design, have different operating speeds and injector sizes that may account for some of the observed differences in their brake specific emissions. However, it is not certain what the exact effects these variables have on the engines' emission characteristics. The various operating (and, hence, test) speeds of these engines are given in Table 2 of Section III. However, the 6V-71 engines were tested at 1000 and 1600 rpm, speeds which more adequately reflect typical engine operation in an intracity bus. This is the only instance in this project where the engine test speeds used were different from those specified in the Federal Test procedure. The injector sizes with which the two-cycle test engines were equipped are given in Table 9 of this section.

B. Four-Cycle Engines

The brake specific data for the naturally aspirated and turbocharged four-cycle test engines is presented in Table 10 and illustrated in Figures 41 to 44, inclusive.

The Cummins NH-250 engines exhibited low brake specific values in every category of gaseous emissions. In fact, these engines had the lowest BSHC and $BSNO_2$ of any type of engine in the project. The average BSHC + $BSNO_2$ value of 6.68 easily meets the 1974 Federal limit of 16 g/bhp-hr, and comes close to the 5 g/bhp-hr limit for 1975. These engines also had the lowest average BSCO value of any naturally aspirated engine tested.

The brake specific data for the Cummins V-903 engines require some preliminary remarks. It was mentioned previously (Section IV) that the V-903 engines tested were of two basic configurations. One engine (Truck No. 415) was rated 320 hp at 2600. The four remaining engines were rated 240 hp at 2400 rpm. This lower rating, a standard option offered by Cummins, is obtained by reducing the injection pump delivery pressure (and, hence, the fuel rate) and by modifying the high speed governor setting.

The 320-hp engine had brake specific emissions similar to those of the NH-250 engines. However, the derated V-903 models had BSHC values up to 12 times that of the 320-hp engine. Conversation with the engine manufacturer produced several possible explanations for this anomoly, such as a cracked injector cup, an injector tip with a partially blocked orifice, or some other condition which would cause fuel to be sprayed directly on the cylinder wall or piston crown. It was decided, with the concurrence of the Project Officer, not to delve into the exact cause of the problem, since to do so would have involved removal of the

TABLE 10. BRAKE SPECIFIC EMISSIONS FOR VEHICLES POWERED BY FOUR-CYCLE ENGINES

Engine: Cummins NH-250
Vehicle: Intercity Truck-Tractor

		g/bhp-hr				
No.	Mileage	BSHC	BSCO	BSNO	$BSNO_2$	$BSHC + BSNO_2$
21	50,738	0.38	6.60	4.15	6.36	6.74
22	71,829	0.32	5.94	4.36	6.68	7.00
62	161,664	0.28	5.42	4.08	6.25	6.53
15743	76,652	0.30	3.65	4.62	7.08	7.38
15744	74,184	0.30	4.35	4.69	7.19	7.49
15745	112,844	0.16	5.18	4.04	6.19	6.35
15746	101,749	0.21	5.26	4.34	6.65	6.86
24658	19,168	0.39	3.52	4.28	6.56	6.95
26353	37,369	0.39	4.65	3.53	5.41	5.65
26354	39,787	0.53	4.42	3.44	5.27	5.80
Average		0.33	4.90	4.15	6.36	6.68
Mean Deviation		0.08	0.78	0.30	0.47	0.47
Standard Deviation		0.10	0.97	0.41	0.63	0.61
Coefficient of Variation		0.30	0.20	0.10	0.10	0.09
Engine: Cummins V-903						
Vehicle: Intercity Truck-Tractor						
415	85,515	0.52	5.32	5.04	7.73	8.25
966	41,027	1.84	3.97	4.56	6.99	8.83
968	47,079	6.26	5.92	3.66	5.61	11.87
970	43,407	4.60	4.64	4.72	7.24	11.84
972	40,865	5.82	6.66	4.22	6.47	12.29
Average		3.81	5.30	4.44	6.81	10.62
Mean Deviation		2.10	0.80	0.42	0.61	1.66
Standard Deviation		2.52	1.05	0.57	0.81	1.91
Coefficient of Variation		0.66	0.20	0.13	0.12	0.18
Engine: Cummins NTC-335						
Vehicle: Intercity Truck-Tractor						
20	65,013	0.50	2.97	6.17	9.46	9.96
144	87,491	0.38	2.80	6.97	10.68	11.06
458	126,772	0.48	2.40	7.10	10.88	11.36
6213	114,382	0.49	2.96	6.40	9.81	10.30
Average		0.46	2.78	6.66	10.21	10.67
Mean Deviation		0.04	0.19	0.38	0.57	0.54
Standard Deviation		0.06	0.27	0.45	0.68	0.65
Coefficient of Variation		0.13	0.10	0.07	0.07	0.06
Engine: Mack ENDT 673B						
Vehicle: Intracity Truck-Tractor						
60122	10,490	2.29	3.30	8.11	12.44	14.73
60124	9,568	2.25	3.20	10.54	16.16	18.41
Average		2.27	3.25	9.32	14.30	16.57
Engine: Mack ENDT 675						
Vehicle: Intercity Truck-Tractor						
1	109,851	1.70	4.66	7.54	11.56	13.26
5	113,283	1.52	4.94	8.50	13.03	14.55
Average		1.61	4.80	8.02	12.29	13.90

TABLE 10. BRAKE SPECIFIC EMISSIONS FOR VEHICLES POWERED BY FOUR-CYCLE ENGINES (Cont'd)

		g/bhp-hr				
No.	**Mileage**	**BSHC**	**BSCO**	**BSNO**	**BSNO$_2$**	**BSHC + BSNO$_2$**
Engine: Caterpillar 1145 **Vehicle: Intracity Delivery Truck**						
507	7,222	2.62	5.59	7.32	11.22	13.84
510	6,222	3.48	6.22	8.82	13.37	16.85
512	3,438	2.66	5.05	7.38	11.32	13.98
519	17,033	2.98	5.18	6.59	10.10	13.08
527	4,006	3.70	7.50	8.09	12.40	16.10
Average		3.09	5.91	7.62	11.68	14.77
Mean Deviation		0.40	0.76	0.65	1.00	1.36
Standard Deviation		0.49	1.00	0.85	1.30	1.62
Coefficient of Variation		0.16	0.17	0.11	0.11	0.11
Engine: Caterpillar 1150 **Vehicle: Intracity Truck-Tractor**						
880	16,223	3.36	5.84	7.01	10.75	14.11
881	11,781	3.02	6.39	7.04	10.79	13.81
883	11,479	4.20	7.25	6.40	9.81	14.01
884	21,645	2.89	6.98	6.01	9.22	12.11
885	12,752	3.38	6.62	6.04	9.26	12.64
Average		3.37	6.62	6.50	9.97	13.34
Mean Deviation		0.34	0.40	0.42	0.64	0.76
Standard Deviation		0.52	0.54	0.51	0.78	0.90
Coefficient of Variation		0.15	0.08	0.08	0.08	0.07
Engine: GM DH-478 **Vehicle: Intracity Truck-Tractor**						
118	8,578	3.26	6.56	3.58	5.49	8.75
133	10,602	2.16	4.93	5.22	8.00	10.16
137	2,844	3.80	4.72	6.27	9.61	13.41
190	3,200	2.02	6.16	3.83	5.87	7.89
Average		2.81	5.59	4.72	7.24	10.05
Mean Deviation		0.72	0.77	1.02	1.56	1.73
Standard Deviation		0.86	0.90	1.26	1.93	2.43
Coefficient of Variation		0.31	0.16	0.27	0.27	0.24
Engine: International Harvester DV550B **Vehicle: Dump Truck**						
631	17,655	3.52	6.32	5.36	8.21	11.74

injectors. Such a step would have been undesirable as far as the smoke surveillance tests were concerned. In spite of these very high BSHC values, the engines met the 1974 standard for BSHC + $BSNO_2$, mainly because of low observed $BSNO_2$ values. Brake specific CO was comparable to that of the NH-250 engines.

The Cummins NTC-335 engines had the low BSHC of the NH-250; however, the turbocharged engines had about 50 percent more $BSNO_2$ than the naturally aspirated engines. All four of the NTC-335 models met the 1974 Federal limit for BSHC + $BSNO_2$. These engines had the lowest BSCO of any engine in the project.

The two Mack ENDT 673B engines also had very low BSCO, but their BSHC and $BSNO_2$ values were the highest of any turbocharged engines in the project. Hence, the sum of these two latter quantities was high, and one engine was over the 1974 Federal limit. The two ENDT 675 engines tested for gaseous emissions had lower average brake specific HC and NO_2, and higher BSCO, than the 673B engines. Both of the 673 models were under the 1974 limit.

The Caterpillar 1145 and 1150 engines had high average BSHC (greater than 3 g/bhp-hr) and moderately high $BSNO_2$. Two of the five 1145 models were over the 1974 Federal limit for the sum of the contaminants, although the average for the five was under this limit. All five of the 1150 engines were under the limit.

The GM-DH-478 engines also had high BSHC, but the $BSNO_2$ values were low. The average sum of these two quantities was just over 10 g/bhp-hr and hence was lower than for any other engine group except the Cummins NH-250. All four of the DH-478 engines met the 1974 Federal limit. The lone IHC engine in the test fleet produced over 3.5 g/bhp-hr of HC, but had only 8.2 g/bhp-hr of NO_2. Thus, the engine was well below the 1974 standard.

C. Statistical Analysis of Gaseous Emissions Test Data

The brake specific emissions data in this section were analyzed to obtain basic statistical quantities such as the range and frequency distributions, the means or averages, the mean and standard deviations, and the coefficients of variation. The results of this analysis are contained in Table 11.

BSHC - The relative frequency distribution (Figure 45) has its peak in the interval from 0 to 1 g/bhp-hr, then decreases through the higher-valued intervals. This peak is the result of the low BSHC of the Cummins NH-250 and NTC-335 engines and Detroit Diesel 8V-71 engines. The interval from 1 to 2 g/bhp-hr contains most of the values of the Detroit Diesel 6V-71 and 6V-53 engines, and the Mack ENDT 675 engines. The Mack

TABLE 11. STATISTICAL ANALYSIS OF BRAKE SPECIFIC EMISSIONS

BSHC

g/bhp-hr Interval	Frequency	Frequency Percentage	Cumulative Percentage
0 to 0.99	23	39.0	39.0
1 to 1.99	16	27.0	66.0
2 to 2.99	8	13.6	79.6
3 to 3.99	8	13.6	93.2
4 to 4.99	2	3.4	96.6
5 to 5.99	1	1.7	98.3
6 to 6.99	1	1.7	100.0

Range of BSHC Values:	0.16 to 6.26 g/bhp-hr
Average BSHC:	1.75 g/bhp-hr
Mean Deviation:	1.13
Standard Deviation:	1.41
Coefficient of Variation:	0.81

BSCO

g/bhp-hr Interval	Frequency	Frequency Percentage	Cumulative Percentage
2 to 3.99	9	15.2	15.2
4 to 5.99	18	30.5	45.7
6 to 7.99	21	35.6	81.3
8 to 9.99	7	11.9	93.2
10 to 11.99	4	6.8	100.0

Range of BSCO Values:	2.40 to 11.37 g/bhp-hr
Average BSCO:	6.34 g/bhp-hr
Mean Deviation:	1.72
Standard Deviation:	2.14
Coefficient of Variation:	0.34

BSNO$_2$

g/bhp-hr Interval	Frequency	Frequency Percentage	Cumulative Percentage
5 to 6.99	13	22.0	22.0
7 to 8.99	7	11.8	33.8
9 to 10.99	11	18.6	52.4
11 to 12.99	8	13.6	66.0
13 to 14.99	7	11.9	77.9
15 to 16.99	8	13.6	91.5
17 to 18.99	4	6.8	98.3
19 to 20.99	1	1.7	100.0

Range of BSNO$_2$ Values:	5.27 to 19.73 g/bhp-hr
Average BSNO$_2$:	11.14 g/bhp-hr
Mean Deviation:	3.46
Standard Deviation:	4.04
Coefficient of Variation:	0.36

BSHC + BSNO$_2$

g/bhp-hr Interval	Frequency	Frequency Percentage	Cumulative Percentage
5 to 6.99	7	11.9	11.9
7 to 8.99	8	13.6	25.5
9 to 10.99	3	5.1	30.6
11 to 12.99	8	13.6	44.2
13 to 14.99	15	25.3	69.5
15 to 16.99	9	15.2	84.7
17 to 18.99	4	6.8	91.5
19 to 20.99	4	6.8	98.3
21 to 22.99	1	1.7	100.0

Range of BSHC + BSNO$_2$ Values:	5.65 to 21.59 g/bhp-hr
Average BSHC + BSNO$_2$:	12.88 g/bhp-hr
Mean Deviation:	3.43
Standard Deviation:	4.13
Coefficient of Variation:	0.32

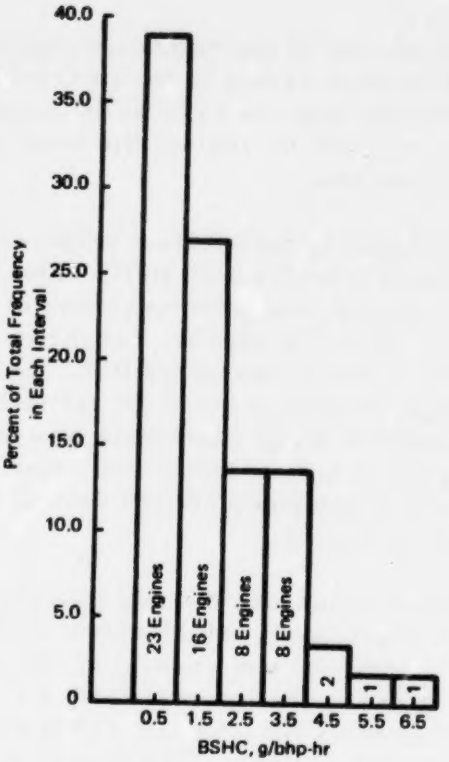


FIGURE 45. RELATIVE FREQUENCY DISTRIBUTION OF BRAKE SPECIFIC HC VALUES
(Chassis Dynamometer Alternative to California ARB Procedure)

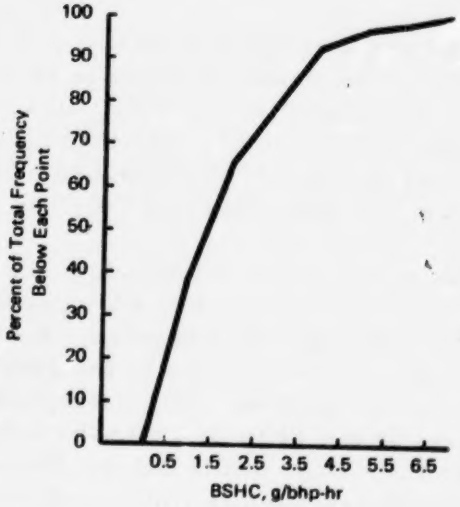


FIGURE 46. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF BRAKE SPECIFIC HC VALUES
(Chassis Dynamometer Alternative to California ARB Procedure)

ENDT 673B engines and several of the midrange engines (Caterpillar 1145 and 1150, and GM DH-478) have values in the interval from 2 to 3 g/bhp-hr. The rest of the midrange engines have BSHC values of 3 to 4 g/bhp-hr. The intervals above 4 g/bhp-hr contain the very high values of the derated Cummins V-903 engines.

The cumulative frequency distribution (Figure 46) is provided to show the percentage of fleet vehicles with BSHC values below or above a given point. The first, second, and third quartiles of these data are approximately 0.5, 1.5, and 2.7 g/bhp-hr, respectively, and divide the data into four equal parts. The range of the BSHC values is 0.16 to 6.26 g/bhp-hr, and the average value is a low 1.75 g/bhp-hr. The standard deviation is 1.41, and yields a large coefficient of variation 0.81. Hence, the data have a high degree of both absolute and relative variation. About 71 percent of the data fell within one standard deviation of the mean, i.e., in the range 0.34 to 3.16 g/bhp-hr.

BSCO--The relative frequency distribution (Figure 47) has its peak in the interval from 6 to 8 g/bhp-hr, which contains the BSCO values for the Detroit Diesel 8V-71 engines, and several of the midrange Caterpillar 1150 and GM DH-478 engines. The interval from 4 to 6 g/bhp-hr has most of the values from the Cummins NH-250 and V-903 engines, the Mack ENDT 675, and the Caterpillar 1145 engines. The lowest interval, from 2 to 4 g/bhp-hr, contains data from the turbocharged Cummins NTC-335 and Mack ENDT 673B engines. The Detroit Diesel 6V-71 and 6V-53 engines populate the intervals above 8 g/bhp-hr. The cumulative frequency distribution is shown in Figure 48. First, second, and third quartiles are approximately 4.7, 6.3, and 7.5 g/bhp-hr, respectively.

The BSCO values have a range of 2.40 to 11.37 g/bhp-hr, with an average of 6.34 g/bhp-hr. The standard deviation is 2.14, so that these data have more absolute variation than the BSHC data. However, the coefficient of variation for the BSCO is 0.34, less than half the relative variation of the HC values. About 68 percent of the BSCO data lies within one standard deviation of the mean, i.e., in the range from 4.20 to 8.48 g/bhp-hr.

BSNO$_2$--The peak of the relative frequency distribution (Figure 49) occurs in the interval from 5 to 7 g/bhp-hr, which contains most of the data for the Cummins NH-250 and V-903 engines. A slightly smaller peak in the interval from 9 to 11 g/bhp-hr is due to the data from the Cummins NTC-335 and Caterpillar 1150 engines. The Caterpillar 1145 and Mack ENDT engines have values in the 11 to 13 g/bhp-hr range. The intervals above 13 g/bhp-hr cover the values of the Detroit Diesel two-cycle engines. The cumulative frequency distribution is illustrated in Figure 50, and estimated first, second, and third quartiles are 7.2, 10.8, and 14.9 g/bhp-hr, respectively.

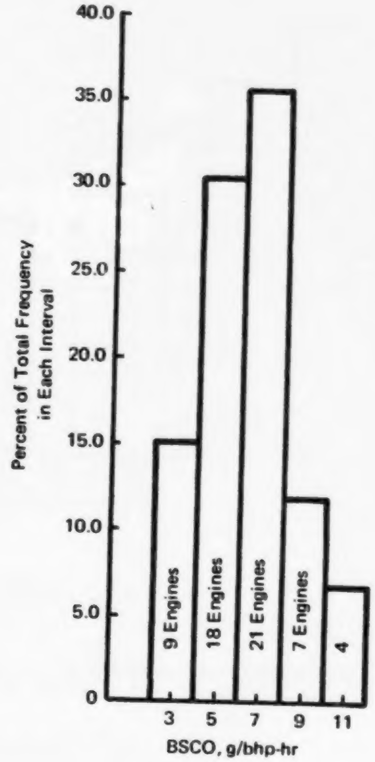


FIGURE 47. RELATIVE FREQUENCY DISTRIBUTION OF BRAKE SPECIFIC CO VALUES (Chassis Dynamometer Alternative to California ARB Procedure)

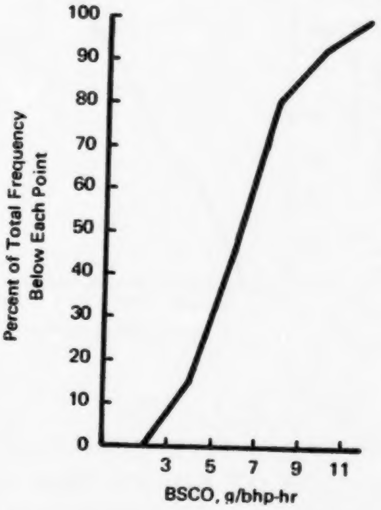


FIGURE 48. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF BRAKE SPECIFIC CO VALUES (Chassis Dynamometer Alternative to California ARB Procedure)

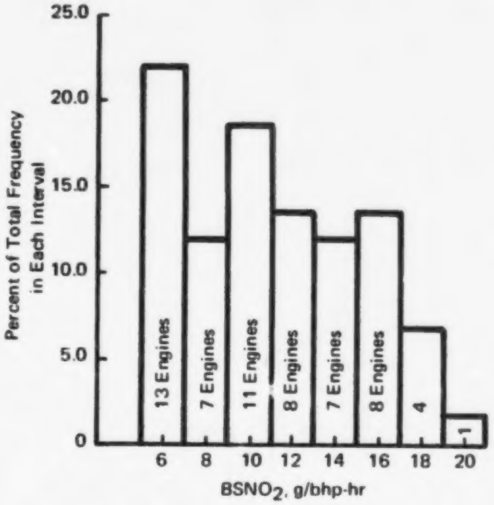


FIGURE 49. RELATIVE FREQUENCY DISTRIBUTION OF BRAKE SPECIFIC NO_2 VALUES
(Chassis Dynamometer Alternative to California ARB Procedure)

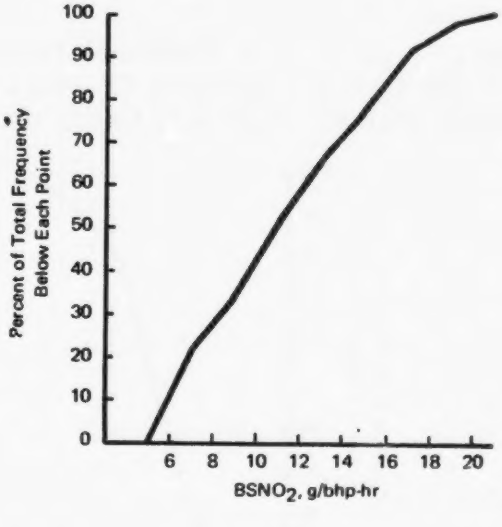


FIGURE 50. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF BRAKE SPECIFIC NO_2 VALUES
(Chassis Dynamometer Alternative to California ARB Procedure)

The $BSNO_2$ data have a range of 5.27 to 19.73 g/bhp-hr, and an average of 11.1 g/bhp-hr. The standard deviation of 4.04 indicates a large absolute variation in the data, but the coefficient of variation is a reasonable 0.36. Approximately 58 percent of the data are within one standard deviation of the mean, i.e., in the range 7.1 to 15.18 g/bhp-hr.

BSHC + $BSNO_2$--The relative frequency has its peak in the interval from 13 to 15 g/bhp-hr, with smaller, but still significant, peaks in intervals to the immediate right and left (Figure 51). The intervals from 13 to 17 g/bhp-hr contain the data from the Detroit Diesel "71" series engines, the Caterpillar 1145 midrange engines, and the turbocharged Mack engines. The interval from 11 to 13 g/bhp-hr has values from the Cummins NTC-335, Cummins V-903, Caterpillar 1150, and IH DV 550B engines. The lowest intervals, from 5 to 9 g/bhp-hr, contain the data from the Cummins NH-250 engines. At the other extreme, the intervals above 17 g/bhp-hr, are found the values from the Detroit Diesel 8V-71 and 6V-53 engines.

The cumulative frequency distribution is shown in Figure 52. About 73 percent of the engines tested met the 1973 California limit of 16 g/bhp-hr, while none were below the 1975 limit of 5 g/bhp-hr. The first, second, and third quartiles are 8.8, 13.4, and 16.1 g/bhp-hr, respectively. These data have a range from 5.65 to 21.59 g/bhp-hr, and an average of 12.88 g/bhp-hr. The standard deviation is 4.13, which is only slightly larger than that of the $BSNO_2$ alone. The coefficient of the variation is 0.32 and indicates the lowest relative variation of the brake specific data. Approximately 63 percent of these data lie within one standard deviation of the mean, or in the range 8.75 to 17.01 g/bhp-hr.

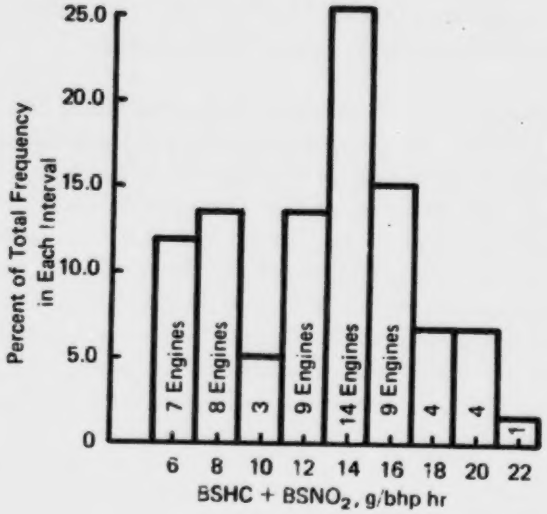


FIGURE 51. RELATIVE FREQUENCY DISTRIBUTION OF BSHC + BSNO$_2$ VALUES
(Chassis Dynamometer Alternative to California ARB Procedure)

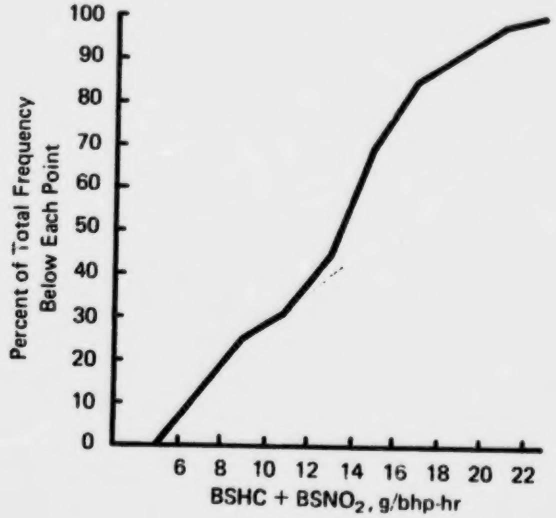


FIGURE 52. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF BSHC + BSNO$_2$ VALUES
(Chassis Dynamometer Alternative to California ARB Procedure)

VII. SUMMARY AND CONCLUSIONS

This project has involved a fleet of 64 vehicles powered by heavy duty diesel engines certified under the Federal smoke compliance procedure. The fleet was tested seven times over a two-year period, at 0, 4, 8, 12, 16, 20 and 24 months of test operation. The test procedure was a chassis dynamometer version of the Federal smoke compliance test, developed at SwRI. The smoke test data have been analyzed to establish the correlation between observed opacity changes and time, vehicle mileage, and type of service. At one of the scheduled smoke tests, 59 of the 64 fleet vehicles were tested for gaseous emissions of hydrocarbons (HC), carbon monoxide (CO), and nitric oxide (NO) by the California ARB 13-mode chassis dynamometer test procedure.

The following remarks summarize the results and conclusions concerning the items of work mentioned above:

1. The chassis version of the Federal Smoke Test procedure, a stationary engine operated test, was successfully applied to all 64 vehicles using the SwRI heavy duty inertia system and tandem axle machine. The chassis procedure is quite repeatable and has the measure of realism that the stationary procedure lacks in that the acceleration in a low gear and after an upshift is done in a truck. The current Federal regulations lack a chassis test alternative, the only method practical for surveillance type testing. This project demonstrated that no matter the make, model, type of chassis, driveline, number of axles or transmission speeds, an acceptable Federal smoke test could be run. This is an important finding in terms of future in-service type testing.

2. The major finding of the project was that smoke levels from trucks and buses powered by diesel engines all deteriorate with a wide range in the rate of this deterioration. The line-haul quality heavy duty engines used in high mileage intercity trucking overall had smoke increases that were nominal, about 5 percent "b" for naturally aspirated and about 10 percent "a" for turbocharged engines. Some engines showed higher values and some less. These trends were found by analysis of results on a periodic inspection basis as well as with mileage. Mid-range engines, those primarily intended for intracity operation in direct competition with gasoline powered trucks, generally produced significantly higher smoke after two years of operation than when new. The lugdown smoke from these naturally aspirated engines was generally the most greatly affected factor though the "a" factor also experiences similar deterioration with time.

3. Somewhat surprising was the affect of time and mileage on line-haul quality engines used in intracity service. While naturally aspirated engines hold-up well in the highly maintained city bus fleet, five turbo-

charged engines in commercial garbage trucks deteriorated rapidly and significantly. Another turbocharged line-haul engine used in low mileage intracity operation likewise had increased smoke, more than anticipated. It appears that, all other factors the same, the way the miles are accumulated may be as or even more important that total mileage on visible exhaust smoke behavior.

4. Many turbocharged and midrange engines demonstrated very brief smoke peaks of 50- to 90-percent opacity during the first acceleration of the Federal smoke test. However, the resulting "a" Factors, which are time-averaged over a 7.5-second interval, are much lower in value than these peak opacities. The current "a" Factor limit of 40-percent opacity was exceeded only by turbocharged engines in the test fleet.

5. Cumulative relative frequency statistics for the two year fleet test were used to determine percentage levels of smoke relative to 1970 and 1974 Federal smoke limits. After one year of operation, some 87 percent of the fleet had higher "a" or "b" Factors than at the first test. One "a" Factor and two "b" Factors were over the 1970 limits at the fourth inspection. At the last inspection, where only a part of the intracity vehicles remained,79 percent of the vehicles were below the Federal "a" Factor and 54 percent of the vehicles were below the "b" Factor.

6. The analysis of variance indicated that the eleven engine makes and models of which there were more than one, consistently produced "a" and "b" smoke factors that were statistically different. Of the five other pairings analyzed, fairly consistent and statistically significant differences were noted for two stroke versus four-stroke and turbocharged versus naturally aspirated engines, especially of the four stroke engine group. The type of service, whether intracity or intercity, or type of engine in intracity service, whether mid-range or line-haul quality, seemed to make little or no difference. Caution must be used in the interpretation of the last three inspection results since mainly the intracity type midrange engines remained in the fleet after the first 12 to 16 months.

7. Forty-three of the 59 engines (73 percent) tested for gaseous emissions met the 1973 California limit of 16 g/bhp-hr for BSHC + $BSNO_2$. The two-cycle engines and turbocharged Mack ENDT 673B engines had the highest average values of this sum, while the Cummins NH-250 engines had the lowest values, both individual and average. No engine met the 1975 California limit of 5 g/bhp-hr. The four-cycle engines tested had lower BSCO that the two-cycle engines. Of these four-cycle engines, the turbocharged models generally had lower BSCO than the naturally aspirated engines. However, all engines tested were well within the 1973 and 1975 California limits of 40 and 25 g /bhp-hr, respectively.

8. The Cummins NHC-250 and NTC-335 engines, along with the

two-cycle 8V-71N engines, had the lowest average brake specific HC values of any engines tested. The highest BSHC values belonged to the speed-derated Cummins V-903 and the midrange four-cycle engines. The Cummins NH-250 and V-903 models, and the GM DH-478 engines, had the lowest average brake specific NO_x, expressed here as $BSNO_2$. The turbocharged four-cycle engines generally had higher $BSNO_2$ than the naturally aspirated four-cycle engines. The highest average $BSNO_2$ belonged to the two-cycle engines in the fleet.

Based on the success of this program to indicate how well the manufacturer is meeting the intent of the 1970 Federal Smoke Law and how well the engines hold-up in the field, it seems appropriate to recommend another such project for 1974 calendar year diesels in heavy duty service. This project should be initiated soon, so as to develop the fleet as much in advance of test work as possible. Gaseous emissions of HC, CO and NO_x should also be included in the surveillance activity as they are featured in the 1974 regulations along with smoke.

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7. "1970 Federal Diesel Smoke Standards," Diesel and Gas Turbine Progress, November 1969, p. 35.

8. Federal Register, Volume 35, No. 219, November 10, 1970.

9. Federal Register, Volume 37, No. 221, November 15, 1972.

10. California Exhaust Emissions Standards, Test and Approval Procedures for Diesel Engines in 1973 and Subsequent Model Year Vehicles Over 6,001 Pounds Gross Vehicle Weight (Chassis Dynamometer Procedure)

11. Bascom, R. C., and Hass, G. C., "A Status Report on the Development of the 1973 California Diesel Emissions Standards" SAE paper No. 700671, presented at the National West Coast Meeting, Los Angeles, California, August 24-27, 1970.

APPENDIX A

FEDERAL SMOKE TEST PROCEDURE
(*FEDERAL REGISTER*, VOL. 35, NO. 219, NOV. 10, 1970)

FEDERAL REGISTER

VOLUME 35 • NUMBER 219
Tuesday, November 10, 1970 • Washington, D.C.

PART II

Department of Health, Education, and Welfare

Office of the Secretary

•

Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines

THE NATIONAL ARCHIVES OF THE UNITED STATES • 1934 •

(iii) When the engine reaches the speed required in subdivision (ii) of this subparagraph, the throttle shall be moved rapidly to the closed position and the preselected load required to perform the acceleration in subdivision (iv) of this subparagraph shall be applied. The engine speed shall be reduced to the speed of maximum rated torque or 60 percent of rated speed (whichever is higher), with ±50 r.p.m. Smoke emissions during this transitional mode are not used in determining smoke emissions to compare with the standard.

(iv) The throttle shall be moved rapidly to the full-throttle position and the engine accelerated against the preselected dynamometer load such that the engine speed reaches 95 to 100 percent of rated speed in 10±2 seconds.

(3) *Lugging mode*. (i) Proceeding from the acceleration mode, the dynamometer controls shall be adjusted to permit the engine to develop maximum horsepower at rated speed. Smoke emissions during this transitional mode are not used in determining smoke emissions to compare with the standard.

(ii) Without changing the throttle position, the dynamometer controls shall be adjusted gradually to slow the engine to the speed of maximum torque or to 60 percent of rated speed, whichever is higher. This engine lugging operation shall be performed smoothly over a period of 35±5 seconds. The rate of slowing of the engine shall be linear, within ±100 r.p.m.

(4) *Engine unloading*. After completion of the lugging mode in subparagraph (3)(ii) of this paragraph, the dynamometer and engine shall be returned to the idle condition described in subparagraph (1) of this paragraph.

(b) The procedures described in paragraph (a) (1) through (4) of this section shall be repeated until the entire cycle has been run three times.

§ 85.123 Dynamometer and engine equipment.

The following equipment shall be used for smoke emission testing of engines on engine dynamometers.

(a) An engine dynamometer with adequate characteristics to perform the test cycle described in § 85.122.

(b) An engine cooling system having sufficient capacity to maintain the engine at normal operating temperatures during conduct of the prescribed engine tests.

(c) A noninsulated exhaust system extending 12±2 feet from the exhaust manifold of the engine and presenting an exhaust back pressure within ±0.2 inches Hg of the upper limit at maximum rated horsepower, as established by the engine manufacturer in his sales and service literature for vehicle application. A conventional automotive muffler of a size and type commonly used with the engine being tested shall be employed in the exhaust system during smoke emission testing. The terminal 2 feet of the exhaust pipe shall be of circular cross section and be free of elbows and bends. The end of the pipe shall be cut off squarely. The terminal 2 feet of the exhaust pipe shall have a diameter in accordance with the engine being tested, as specified below:

Maximum rated horsepower	*Exhaust pipe size*
Less than 101	2"
101–200	3"
201–300	4"
301 or more	5"

(d) An engine air inlet system presenting an air inlet restriction within ±1-inch of water of the upper limit for the engine operating condition which results in maximum air flow, as established by the engine manufacturer in his sales and service literature, for the engine being tested.

§ 85.124 Smoke measurement system.

(a) *Schematic drawing*. The following figure (fig. 7) is a schematic drawing of the optical system of the light extinction meter.

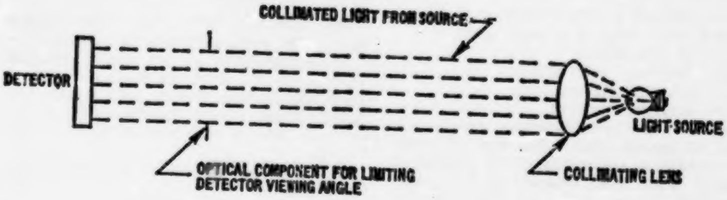

COLLIMATED LIGHT FROM SOURCE
DETECTOR
LIGHT SOURCE
OPTICAL COMPONENT FOR LIMITING DETECTOR VIEWING ANGLE
COLLIMATING LENS

Figure. 7. USPHS smokemeter optical system (schematic).

(b) *Equipment*. The following equipment shall be used in the system:

(1) Adapter—the smokemeter optical unit may be mounted on a fixed or movable frame. The normal unrestricted shape of the exhaust plume shall not be modified by the adapter, the meter, or any ventilation system used to remove the exhaust from the test site.

(2) Smokemeter (light extinction meter)—continuous recording, full-flow light obscuration meter. It shall be positioned near the end of the exhaust pipe so that a built-in light beam traverses the exhaust smoke plume which issues from the pipe at right angles to the axis of the plume. The light source is an incandescent lamp operated at a constant voltage of not less than 15 percent of the manufacturer's specified voltage. The lamp output is collimated to a beam with a nominal diameter of 1.125 inches. The angle of divergence of the collimated beam shall be within 4° included angle. A light detector, directly opposed to the light source, measures the amount of light blocked by the smoke in the exhaust. The detector sensitivity is restricted to the visual range and comparable to that of the human eye. A collimating tube with apertures equal to the beam diameter is attached to the detector. It restricts the viewing angle of the detector to within 16° included angle. An amplified signal corresponding to the amount of light blocked is recorded continuously on a remote recorder. An air curtain across the light source and detector window assemblies may be used to minimize deposition of smoke particles on those surfaces provided that it does not measurably affect the opacity of the plume. The meter consists of two units, an optical unit and a remote control unit. Light extinction meters employing substantially identical measurment principles and producing substantially equivalent results but which employ other electronic and optical techniques may be used only after having been approved in advance by the Secretary.

(3) Recorder—a continuous recorder, with variable chart speed over a minimal range of 0.5 to 8.0 inches per minute (or equivalent) and an automatic marker indicating 1-second intervals shall be used for continuously recording the transient conditions of exhaust gas opacity, engine r.p.m. and torque. The recorder scale for opacity shall be linear and calibrated to read from 0 to 100 percent opacity full scale. The opacity trace shall have a resolution within 1 percent opacity. The recorder scale for engine r.p.m. and the recorder scale for observed engine torque shall be linear and shall have full scale calibration such as to facilitate chart reading. The r.p.m. trace shall have a resolution within 30 r.p.m. The torque trace shall have a resolution within 10 lb.-ft. Any means other than strip chart recorder may be used provided it produces a permanent visual data record of quality equal to or better than that described above.

(4) The recorder used with the smokemeter shall be capable of full-scale deflection in 0.5 second or less. The smokemeter-recorder combination may be damped so that signals with a frequency higher than 10 cycles per second are attenuated. A separate low-pass electronic filter with the following performance characteristics may be installed between the smokemeter and the recorder to achieve the high-frequency attenuation.

(i) 3 decibel point—10 cycles per second.

(ii) Insertion loss-zero ±0.5 decibels.

(iii) Selectivity—12 decibels per octave above 10 cycles per second.

(iv) Attenuation—27 decibles down at 40 cycles per second minimum.

(c) *Assembling equipment*. (1) The optical unit of the smokemeter shall be mounted radially to the exhaust pipe so that the measurement will be made at right angles to the axis of the exhaust plume. The distance from the optical centerline to the exhaust pipe outlet shall be 1.0 to 1.5 pipe diameters but never less than 4 inches. The full flow of the exhaust stream shall be centered between the source and detector apertures (or windows and lenses) and on the axis of the light beam.

(2) Power shall be supplied to the control unit of the smokemeter in time at least 15 minutes prior to testing to allow for stabilization.

§ 85.125 Information to be recorded.

The following information shall be recorded with respect to each test:

(a) Test number.

(b) Date and time of day.

(c) Instrument operator.

(d) Engine operator.

(e) Engine Identification numbers—Date of manufacture—Number of hours of operation accumulated on engine—Engine Family—Exhaust pipe diameter—Fuel injector type—Maximum measured fuel rate at maximum measured torque and horsepower—Air aspiration system—Low idle r.p.m.—Maximum governed r.p.m.—Maximum measured horsepower at r.p.m.—Maximum measured torque at r.p.m.—Exhaust system back pressure—Air inlet restriction.

(f) Smokemeter. Number—Zero control setting—Calibration control setting—Gain.

(g) Recorder chart. Identify zero traces—Calibration traces—Idle traces—Acceleration and lug-down test traces—Start and finish of each test.

(h) Ambient temperature in dynamometer testing room.

(i) Engine intake air temperature and humidity.

(j) Barometric pressure.

(k) Observed engine torque.

§ 85.126 Instrument checks.

(a) The smokemeter shall be checked according to the following procedure prior to each test:

(1) The optical surfaces of the optical section shall be checked to verify that they are clean and free of foreign material and fingerprints.

(2) The zero control shall be adjusted under conditions of "no smoke" to give a recorder trace of zero.

(3) Calibrated neutral density filters having approximately 20 percent and 40 percent opacity shall be employed to check the linearity of the instrument. The filter(s) shall be inserted in the light path perpendicular to the axis of the beam and adjacent to the opening from which the beam of light from the light source emanates, and the recorder response shall be noted. The nominal opacity valve of the filter will be confirmed by the Secretary. Deviations in excess of 1 percent of the nominal opacity shall be corrected.

(b) The instruments for measuring and recording engine r.p.m., engine torque, air inlet restrictions, exhaust system back pressure, etc., which are used in the tests prescribed herein shall be calibrated from time to time in accordance with good technical practice.

§ 85.127 Test run.

(a) The temperature of the air supplied to the engine shall be between 68° F. and 86° F. The observed barometric pressure shall be between 28.5 inches and 31 inches Hg. Higher air temperature or lower barometric pressure may be used, if desired, but no allowance will be made for possible increased smoke emissions because of such conditions.

(b) The governor and fuel system shall have been adjusted to provide engine performance at the levels specified by the engine manufacturer for maximum rated horsepower and maximum rated torque. These specifications shall be reported in accordance with § 85.51 (b)(3).

(c) The following steps shall be taken for each test:

(1) Start cooling system.

(2) Starting with a warmed engine, determine by experimentation the dynamometer inertia and dynamometer load required to perform the acceleration in the dynamometer cycle for smoke emission tests (§ 85.122(a)(2)). In a manner appropriate for the dynamometer and controls being used, arrange to conduct the acceleration mode.

(3) Install smokemeter optical unit and connect it to the recorder. Connect the engine r.p.m. and torque sensing devices to the recorder.

(4) Turn on purge air to the optical unit of the smokemeter, if purge air is used.

(5) Check and record zero and span settings of the smokemeter recorder at a chart speed of approximately 1 inch per minute. (The optical unit shall be retracted from its position about the exhaust stream if the engine is left running.)

(6) Precondition the engine by operating it for 10 minutes at maximum rated horsepower.

(7) Proceed with the sequence of smoke emission measurements on the engine dynamometer as prescribed in § 85.122.

(8) During the test sequence of § 85.-122, continuously record smoke measurements, engine r.p.m. and torque at a chart speed of approximately 1 inch per minute minimum during the idle mode and transitional modes and 8 inches per minute minimum during the acceleration and lugging modes.

(9) Turn off engine.

(10) Check zero and reset if necessary and check span of the smokemeter recorder by inserting neutral density filters. If either zero or span drift is in excess of 2 percent opacity, the test results shall be invalidated.

§ 85.128 Chart reading.

(a) The following procedure shall be employed in reading the smokemeter recorder chart.

(1) Locate the acceleration mode (§ 85.122(a)(2)) and the lugging mode (§ 85.122(a)(3)) on the chart. Divide each mode into ½-second intervals beginning at the start of each mode Determine the average smoke reading during each ½-second interval except those recorded during the transitional portions of the acceleration mode (§ 85.122(a)(2)(iii)) and the lugging mode (§ 85.122(a)(3)(i)).

(2) Locate and record the 15 highest ½-second readings during the acceleration mode of each dynamometer cycle.

(3) Locate and record the five highest ½-second readings during the lugging mode of each dynamometer cycle.

§ 85.129 Calculations.

(a) Average the 45 readings in § 85.128 (a)(2) and designate the value as "a".

(b) Average the 15 readings in § 85.128 (a)(3) and designate the value as "b".

§ 85.130 Test engines.

(a) The engines covered by the application for certification will be divided into engine families based upon the criteria outlined in § 85.89(a).

(b) Emission data engines:

(1) Engines will be chosen to be run for emission data based upon engine family groupings. Within each engine family, the requirements of this paragraph must be met.

(2) Engines of each engine family will be divided into groups based upon exhaust emission control system. Two engines of each engine-system combination shall be run for smoke emission data as prescribed in § 85.132(b). Within each combination, the engines that feature the highest fuel feed per stroke, primarily at the speed of maximum rated torque and secondarily at rated speed, will be selected. In the case where more than one engine in an engine-system combination have the highest fuel feed per stroke, the engine with the highest maximum rated torque will be selected.

(c) Durability data engines:

(1) One engine from each engine-system combination shall be tested for lifetime smoke emission data as prescribed in § 85.132(c). Within each combination, the engine which features the highest fuel feed per stroke, primarily at rated speed and secondarily at the speed of maximum rated torque, will be selected for durability testing. In the case where more than one engine in an engine-system combination has the highest fuel feed per stroke, the engine with the highest maximum rated horsepower will be selected for durability testing.

(2) A manufacturer may elect to operate and test additional engines to represent any engine-system combination. The additional engines must be of the same model and fuel system as the engine selected in accordance with the provisions of subparagraph (1) of this paragraph. Notice of an intent to test additional engines shall be given to the Secretary not later than 30 days following notification of the test fleet selection.

(d) Any manufacturer whose projected sales of new motor vehicle engines subject to this subpart for the model year for which certification is sought is less than 200 engines may request a reduction in the number of test engines determined in accordance with the foregoing provisions of this section. The Secretary may agree to such lesser number as he determines would meet the objectives of this procedure.

(e) In lieu of testing an emission data or durability data vehicles elected under paragraph (b) or (c) of this section and submitting data therefor, a manufacturer may, with the prior written approval of the Secretary, submit data on a similar vehicle for which certification has previously been obtained.

§ 85.131 Maintenance.

(a) (1) Maintenance on the engines and fuel systems of durability engines may be performed only under the following provisions:

(i) One major engine servicing to manufacturer's specifications may be performed at 500 hours (±8 hours) of dynamometer operation. A major engine servicing shall be restricted to the following:

(*a*) Adjust low idle speed.
(*b*) Adjust valve lash if required.
(*c*) Adjust injector timing.
(*d*) Adjust governor.
(*e*) Clean and service injector tips.

(ii) Injectors may be changed if a persistent misfire is detected.

(iii) Normal engine lubrication services (engine oil change and oil filter, fuel filter, and air filter servicing and adjustment of drive belt tension, and engine bolt torque as required) will be allowed at manufacturer's recommended intervals.

(iv) Readjustment of the engine fuel rates may be performed only if there is a problem of dropping below 95 percent of maximum rated horsepower at 95–100 percent rated speed.

(v) Leaks in the fuel system, engine lubrication system and cooling system may be repaired.

(vi) Any other engine or fuel system maintenance or repairs will be allowed only with the advanced approval of the Secretary.

(2) Allowable maintenance on emission data engines shall be limited to the adjustment of engine low idle speed at the 125-hour test point.

(b) Complete emission tests (see §§ 85.121–85.129) shall be run before and after any engine maintenance which may reasonably be expected to affect emissions. These test data shall be supplied to the Secretary immediately after the tests, along with a complete record of all pertinent maintenance, including an engineering report of any malfunction diagnosis and the corrective action taken. In addition, all test data and maintenance reports shall be compiled and provided to the Secretary in accordance with § 85.53.

(c) If the Secretary determines that maintenance or repairs performed have resulted in a substantial change to the engine-system combination, the engine shall not be used as a durability data engine.

§ 85.132 Service accumulation and emission measurements.

Service accumulation shall be accomplished by operation of an engine on a dynamometer.

(a) Emission data engines: Each engine shall be operated on a dynamometer for 125 hours with the dynamometer and engine adjusted so that the engine is operating at 95–100 percent of rated speed and at least 95 percent of maximum rated horsepower. During such operation, the engine shall be run at the exhaust back pressure specified in § 85.123(c) and the air inlet restriction specified in § 85.123(d) except that the tolerances shall be ±0.5 inches of Hg. and ±3 inches of water respectively. Exhaust smoke tests shall be conducted at zero and 125 hours of operation.

(b) Durability data engines: Each engine shall be operated on a dynamometer for 1,000 hours with the dynamometer and engine adjusted so that the engine is operating at 95–100 percent of rated speed and at least 95 percent of maximum rated horsepower. During such operation, the engine shall be run at the exhaust back pressure specified in § 85.123(c) and the air inlet restriction specified in § 85.123(d) except that the tolerances shall be ±0.5 inches of Hg. and ±3 inches of water respectively. Exhaust smoke measurements shall be made at zero hours and at each 125 hours of operation. All results except the zero hour results shall be used to establish the deterioration factors (see § 85.133).

(c) All tests required by this subpart to be conducted after 125 hours of dynamometer operation or at any multiple of 125 hours may be conducted at any accumulated hours within 8 hours of 125 hours or the appropriate multiple of 125 hours, respectively.

(d) The results of each emission test shall be supplied to the Secretary immediately after the test. In addition, all test data shall be compiled and provided to the Secretary in accordance with § 85.53.

(e) Whenever the manufacturer proposes to operate and test an engine which may be used for emission or durability data, he shall provide the zero hour test data to the Secretary and make the engine available for such testing under § 85.54 as the Secretary may require before beginning to accumulate hours on the engine. Failure to comply with this requirement shall invalidate all test data submitted for this engine.

(f) Once a manufacturer begins to operate an emission data or durability data engine, as indicated by compliance with paragraph (e) of this section, he shall continue to run the engine to 125 hours or 1,000 hours, respectively, and the data from the engine shall be used in the calculations under § 85.133. Discontinuation of an engine shall be allowed only with the prior written consent of the Secretary.

§ 85.133 Compliance with emission standards.

(a) The emission standards in the regulations in this part apply to the lifetime emission of engines in public use. Prior to certification, lifetime emissions can be obtained by projection of test data to lifetime normal service. Lifetime normal service or its equivalent is taken to be 2,000 hours of prescribed dynamometer operation.

(b) It is expected that the opacity of exhaust emissions will change with use of the engine. It is assumed that the emission level corresponding to 1,000 hours of prescribed dynamometer operation is the average emission of an engine over its lifetime.

(c) The procedure for determining compliance with exhaust smoke emission standards in heavy duty diesel engines is as follows:

(1) Emission deterioration factors for the acceleration mode (designated as "A") and the lugging mode (designated as "B") shall be established separately for each engine-system combination.

(i) The applicable results to be used in determining the deterioration factors for each combination shall be:

(*a*) All emission data from the tests required under § 85.132(b), except the zero hour tests. This shall include the official test results, as determined in § 85.54, for all tests conducted on all durability engines of the combination selected under § 85.130(c) (including all engines elected to be operated by the manufacturer under § 85.130(c)(2)).

(*b*) All emission data from the tests conducted before and after the maintenance provided in § 85.131(a)(1)(i).

(ii) All applicable results shall be plotted as a function of the hours on the system, rounded to the nearest hour, and the best fit straight lines, fitted by the method of least squares, shall be drawn through these data points. The interpolated 125 and 1,000 hour points on this line must be within the standard provided in § 85.41 or the data shall not be used in calculation of a deterioration factor.

(iii) The deterioration factors will be calculated as follows:

A-percent opacity "a", interpolated to 1,000 hours, minus percent opacity "a," interpolated to [illegible] hours.
B-percent opacity "b", interpolated to 1,000 hours, minus percent opacity "b", interpolated to 125 hours.

(2) The "percent opacity" values to compare with the standards shall be the opacity values "a" and "b" for each emission data engine within an engine-system combination to which are added the respective factors "A" and "B" of subparagraph (1) of this paragraph for that engine-system combination: *Provided*, That if a deterioration factor as computed in subparagraph (1) of this paragraph is less than zero, that deterioration factor shall be zero for the purposes of this subparagraph.

(3) Every test engine of an engine family must comply with all applicable standards, as determined in subparagraph (2) of this paragraph, before any engine in that family will be certified.

Subpart J—Test Procedures for Engine Exhaust Emissions (Heavy Duty Diesel Engines)

§ 85.120 Introduction.

(a) The procedures described in this subpart will be the test program to determine the conformity of heavy duty diesel engines with the applicable standards set forth in this part:

(b) The test consists of a prescribed sequence of engine operating conditions on an engine dynamometer with continuous examination of the exhaust gases. The test is applicable equally to controlled engines equipped with means for preventing, controlling, or eliminating smoke emissions and to uncontrolled engines.

(c) The test is designed to determine the opacity of smoke in exhaust emissions during those engine operating conditions which tend to promote smoke from diesel-powered vehicles.

(d) The test procedure begins with a warm engine which is then run through preloading and preconditioning operations. After an idling period, the engine is operated through acceleration and lugging modes during which smoke emission measurements are made to compare with the standards. The engine is then returned to the idle condition and the acceleration and lugging modes are repeated. Three sequences of acceleration and lugging constitute the full set of operating conditions for smoke emission measurement.

§ 85.121 Diesel fuel specifications.

(a) The diesel fuels employed shall be clean and bright, with pour and cloud points adequate for operability. The fuels may contain nonmetallic additives as follows: cetane improver, metal deactivator, antioxidant, dehazer, antirust, pour depressant, dye, and dispersant.

(b) Fuel meeting the following specifications, or substantially equivalent specifications approved by the Secretary, shall be used in exhaust emission testing. The grade of fuel recommended by the engine manufacturer, commercially designated as "Type 1-D" or "Type 2-D", shall be used.

Item	ASTM test method No.	Type 1-D	Type 2-D
Cetane	D 613	48-54	42-50
Distillation range	D 86		
IBP, °F		330-390	340-400
10 percent point, °F		370-430	400-460
50 percent point, °F		410-480	470-540
90 percent point, °F		460-520	540-610
EP, °F		500-560	580-660
Gravity, °API	D 287	40-44	33-37
Total sulfur, percent	D 129 or D 2622	0.05-0.20	0.2-0.5
Hydrocarbon composition	D 1319		
Aromatics, percent		8-15	27 (Min.)
Paraffins, Naphthenes, Olefins		Remainder	Remainder
Flash point, °F (Min.)	D 93	120	130
Viscosity, centistokes	D 445	1.6-2.0	2.0-3.2

(c) Fuel meeting the following specifications, or substantially equivalent specifications approved by the Secretary, shall be used in service accumulation. The grade of fuel recommended by the engine manufacturer, commercially designated as "Type 1-D" or "Type 2-D", shall be used.

Item	ASTM test method No.	Type 1-D	Type 2-D
Cetane	D 613	48-54	42-55
Distillation range	D 86		
IBP, °F		330-390	340-410
10 percent point, °F		370-430	400-460
50 percent point, °F		410-480	470-540
90 percent point, °F		460-520	560-610
EP, °F		500-560	580-660
Gravity, °API	D 287	40-44	33-40
Total sulfur, percent	D 129 or D 2622	0.05-0.20	0.2-0.5
Flash point, °F (Min.)	D 93	120	130
Viscosity, centistokes	D 445	1.6-2.0	2.0-3.2

(d) The type fuel, including additive and other specifications, used under paragraphs (b) and (c) of this section shall be reported in accordance with § 85.51(b)(3).

§ 85.122 Dynamometer operation cycle for smoke emission tests.

(a) The following sequence of operations shall be performed during engine dynamometer testing of smoke emissions, starting with the dynamometer preloading determined and the engine preconditioned (§ 85.127(c)).

(1) *Idle mode.* The engine is caused to idle for 5 to 5.5 minutes at the manufacturer's recommended low idle speed. The dynamometer controls shall be set to provide minimum load by turning the load switch to the "off" position or by adjusting the controls to the minimum load position.

(2) *Acceleration mode.* (i) The engine speed shall be increased to 200±50 r.p.m. above the manufacturer's recommended low idle speed within 3 seconds.

(ii) The engine shall be accelerated at full-throttle against the inertia of the engine and dynamometer or alternately against a preselected dynamometer load such that the engine speed reaches 85 to 90 percent of rated speed in 5±1.5 seconds.

APPENDIX B

CALIFORNIA EXHAUST EMISSIONS STANDARDS, TEST AND APPROVAL PROCEDURES FOR DIESEL ENGINES IN 1973 AND SUBSEQUENT MODEL YEAR VEHICLES OVER 6,001 POUNDS GROSS VEHICLE WEIGHT (CHASSIS DYNAMOMETER PROCEDURE)

D. Field Surveillance Chassis Dynamometer Test Procedure

I. Introduction

a) The following procedure may be used in the field surveillance testing of diesel-powered, heavy-duty vehicles.

b) The test procedure consists of a prescribed sequence of engine operating conditions using a vehicle chassis dynamometer with measurement of hydrocarbons, nitric oxide, and carbon monoxide during the same thirteen modes as used in the engine dynamometer procedure except the operating time in each mode is shortened to minimize tire failure problems.

c) This test procedure is similar to the engine dynamometer procedure except that the engine exhaust flow and brake horsepower are obtained from the engine manufacturers' data and fuel rate measurements during the test. Because of this and the greater difficulty in controlling test conditions, this procedure is inherently less accurate than the engine dynamometer procedure.

II. Fuel Specification

a) The fuel used for this procedure shall meet the same specifications required for the engine dynamometer procedure (Section C, II).

III. Instrumentation

a) Instrumentation shall be provided to measure the following:

1. Engine speed: rpm
2. Observed barometer: in. Hg
3. Water vapor pressure: in. Hg
4. Intake air restriction: in. water
5. Exhaust back pressure: in. Hg
6. Intake air temperature: °F
7. Fuel temperature at pump inlet: °F

b) Instrumentation shall be provided to measure the concentration of carbon monoxide, nitric oxide, and hydrocarbons in the exhaust as follows:

1. The determination of the carbon monoxide and nitric oxide concentrations shall be accomplished using sampling and analysis by nondispersive infrared methods using the SAE Recommended Practice #J177 titled "Measurement of Carbon Dioxide, Carbon Monoxide, and Oxides of Nitrogen in Diesel Exhaust" except the time in mode shall be as prescribed in Section D.V.c).

2. The determination of the hydrocarbon concentration shall be accomplished using sampling and analysis by a heated flame ionization detector method using the SAE Recommended Practice #J215 titled "Continuous Hydrocarbon Analysis of Diesel Exhaust" except the time in mode shall be as prescribed in Section D.V.c), 4).

c) Equipment shall be provided to measure the mass fuel consumption rate and to control the temperature of the fuel supplied to the engine. The fuel rate instrumentation must provide a continuous indication of fuel rate (weigh tank systems are not satisfactory). A system incorporating calibrated rotometers (fuel viscosity and temperature affect calibration) or a mass flow meter, a heat exchanger, and float tank similar to that shown in Figure 1 is satisfactory.

IV. Test Conditions

a) The following ranges of test conditions should be maintained as closely as possible during exhaust emission testing: deviations from these conditions will cause increasing errors in brake specific emissions values.

1. Intake air temperature: 85° ± 15° F
2. Barometric pressure: 29.4 in. Hg ± 1 in. Hg
3. Fuel temperature: 100° F ± 10° F
4. Intake restriction: between the manufacturers' published maximum limits of clean air cleaner restriction and dirty air cleaner restriction.
5. Exhaust restriction: typical encountered in the vehicle but no higher than manufacturers' published limit.

V. Test Procedure for Exhaust Emissions

a) Pre -Test Conditioning

Operate the vehicle on the chassis dynamometer with the engine at 85 ± 10% of rated speed and 50 ± 10% of maximum rear wheel horsepower at that speed for at least 15 minutes or until the transmission and rear axle temperatures have stabilized.

b) Selection of Test Conditions

1. Determine the maximum fuel rate for the test engine at the rated and intermediate engine speeds.
2. Obtain curves of engine brake horsepower and exhaust flow as functions of fuel rate for the engine model being tested from the engine manufacturer (Figures 2 and 3).
3. Use the brake horsepower vs. fuel rate data (Fig. 2) to estimate the maximum brake horsepower produced by the test engine at the rated and intermediate speeds. These are the 100% load conditions to be used during the test.
4. Calculate the engine brake horsepower at 75, 50, and 25% load for rated and intermediate speeds using the estimated maximum brake horsepower values from D,V(b) (3) above.

FIGURE 1

FUEL FLOW MEASUREMENT SYSTEM

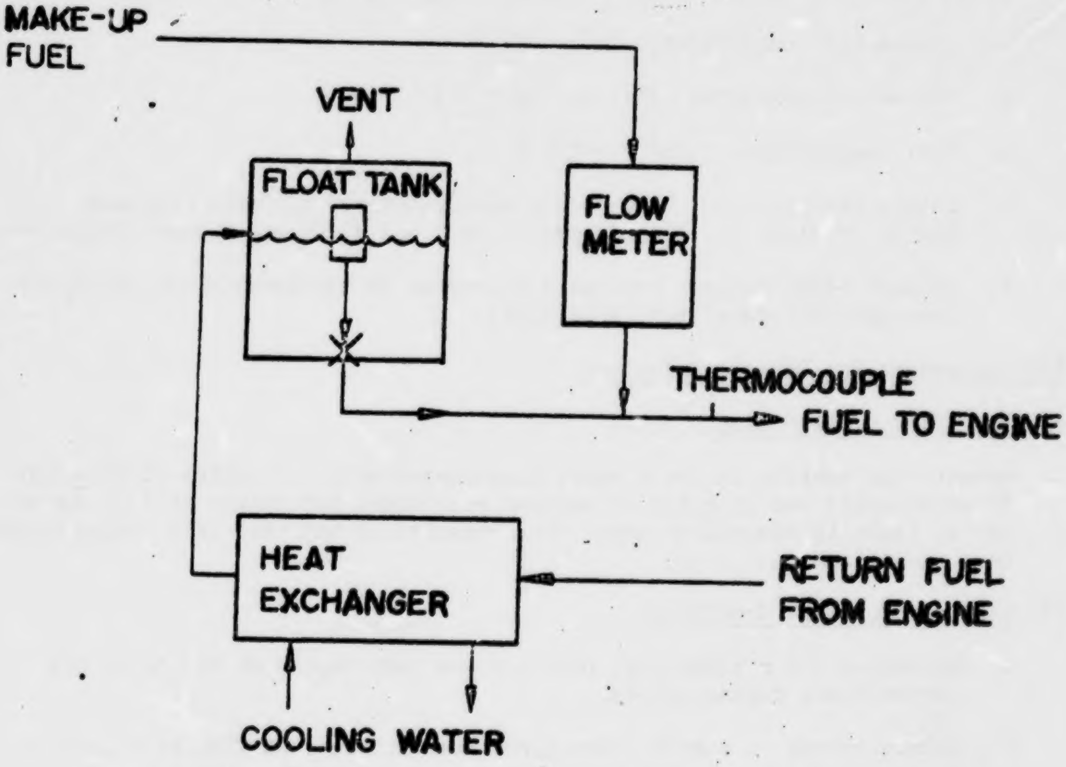

MAKE-UP FUEL
VENT
FLOAT TANK
FLOW METER
THERMOCOUPLE
FUEL TO ENGINE
HEAT EXCHANGER
RETURN FUEL FROM ENGINE
COOLING WATER

Figure 2

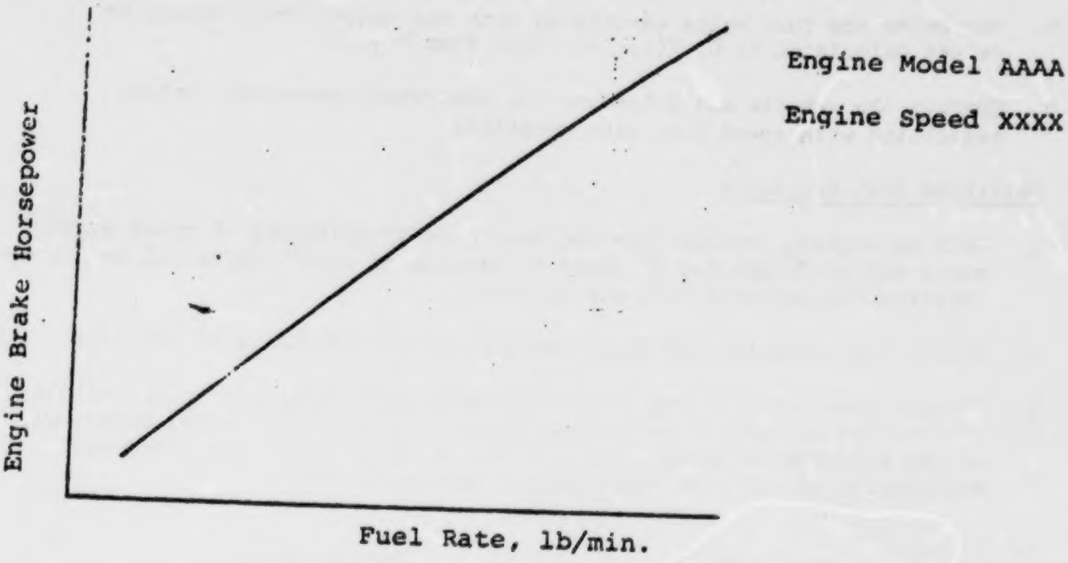
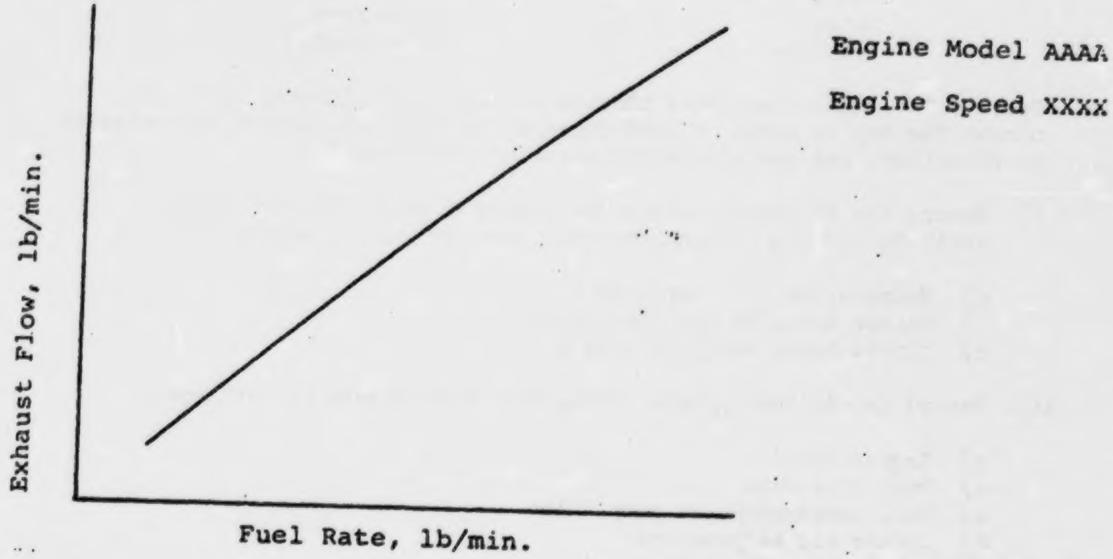


Figure 3



5. Determine the fuel rates associated with the engine brake horsepower values calculated in D, V(b) (4) above from Fig. 2.

6. Operate the vehicle and determine the rear wheel horsepower values associated with speed/fuel rate condition.

c) Emissions Test Procedure

1. Warm up engine, transmission and rear axle by operating at rated engine speed and 30-50 mph for at least 15 minutes or until engine oil and transmission temperatures have stabilized.

2. Record the barometer and vapor pressure at the beginning of the test.

3. Operate the engine at the following modes using fuel rate values within ± 5% of the calculated in Section D,V,(b). Use the rear wheel horsepower values observed in Section D,V,(b) (6) to adjust the accelerator and dynamometer settin s to reach proper test conditions.

Engine Speed	Percent Load
Low Idle	Declutched
Intermediate	Declutched
Intermediate	25%
Intermediate	50%
Intermediate	75%
Intermediate	100%
Low Idle	Declutched
Rated	100%
Rated	75%
Rated	50%
Rated	25%
Rated	Declutched
Low Idle	Declutched

4. Operate the engine for three minutes in each mode allowing up to one minute for engine speed or load changes, at least one minute for emission stablization, and one minute for emission measurement.

i) Record the following during the complete test. Exhaust sample shall be flowing through the analyzers during the entire test.

a) Hydrocarbon analyzer output
b) Carbon monoxide analyzer output
c) Nitric oxide analyzer output

ii) Record the following data during the final minute in each mode:

a) Engine Speed
b) Fuel flow rate
c) Fuel temperature at pump inlet
d) Intake air temperature
e) Intake air restriction
f) Exhaust restriction

d) Chart Reading

1. Locate the last sixty seconds of each mode and determine the average chart reading for hydrocarbons, carbon monoxide, and nitric oxide over this one minute period. (This chart reading procedure shall be followed rather than the times specified in the SAE Recommended Practices referenced in Section D,III(b)).

2. Determine the concentration of HC, CO, and NO (HC_{conc}, CO_{conc}, NO_{conc}) in each mode from the chart reading D,V(d) (1) and from the calibration data. Average the three idle modes.

3. Determine the engine brake horsepower and mass exhaust flow from the manufacturer's data using the fuel rate measured during each mode from Figures 2 and 3.

e) Calculations

1. The test results for the emissions test sequences shall be derived through the following steps:

   i) Calculate the mass emissions for HC, CO, and NO in grams per hour for each mode as follows:

   $$HC_{mass} = 0.0132 \times HC_{conc} \text{ (ppm-carbon)} \times \text{exh mass (lb/min)}$$

   $$CO_{mass} = 0.0263 \times CO_{conc} \text{ (ppm)} \times \text{exh mass (lb/min)}$$

   $$NO_{2mass} = 0.0432 \times NO_{conc} \text{ (ppm)} \times \text{exh mass (lb/min)}$$

   ii) Calculate the weighted BHP, HC_{mass}, CO_{mass}, and NO_{2mass} for each mode by multiplying the value of each by the weighting factor for that mode. The weighting factors are 0.20 for the average idle mode and 0.08 for all other modes.

   iii) Calculate the brack specific emissions for HC, CO, and NO as follows:

   $$BSHC = \frac{\Sigma\,(HC_{mass} \times WF)}{\Sigma\,(BHP \times WF)}$$

   $$BSCO = \frac{\Sigma\,(CO_{mass} \times WF)}{\Sigma\,(BHP \times WF)}$$

   $$BSNO_2 = \frac{\Sigma\,(NO_{2mass} \times WF)}{\Sigma\,(BHP \times WF)}$$

APPENDIX C

TABULAR SUMMARIES OF CHASSIS SIMULATED FEDERAL SMOKE TEST

"a", "b", and "c" Factors by

Engine Groups

All Inspections

TABLE C-1. TWO-CYCLE ENGINES IN INTRACITY SERVICE

Engine: Detroit Diesel 6V-71N (LSN 60 Injectors)
Vehicle: GM Bus

No.	Initial Mileage	First-Round Test, PHS Smoke Opacity, %			Second-Round Test	Second-Round Test, PHS Smoke Opacity, %						Third-Round Test	Third-Round Test, PHS Smoke Opacity, %					
		"a" Factor	"b" Factor	"c" Factor	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Difference*, Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Difference*, Δ"a"	Δ"b"	Δ"c"
815	44,059	5.8	4.7	6.6	22,144	7.2	7.6	8.9	+1.4	+2.9	+2.3	44,794	6.2	4.8	7.2	+0.4	+0.1	+0.6
816	32,427	6.4	6.2	7.3	22,133	7.8	8.1	9.2	+1.4	+1.9	+1.9	45,232	5.5	4.6	6.6	-0.9	-1.6	-0.7
817	45,575	10.2	7.4	12.1	20,973	9.4	9.6	12.5	-0.8	+2.2	+0.4	45,689	9.4	7.3	13.5	-0.8	-0.1	+1.4
818	49,190	6.1	6.4	8.1	22,010	6.4	7.1	8.0	+0.3	+0.7	-0.1	44,561	7.9	7.2	9.5	+1.8	+0.8	+1.4
819	46,277	8.6	8.5	10.4	26,265	7.4	7.5	7.7	-1.2	-1.0	-2.7	47,047	8.3	7.9	9.9	-0.3	-0.6	-0.5
820	43,499	4.6	3.7	5.3	22,091	3.5	3.3	4.2	-1.1	-0.4	-1.1	49,375	5.7	4.8	6.9	+1.1	+1.1	+1.6
821	41,982	6.0	4.8	7.2	26,155	6.7	6.4	8.1	+0.7	+1.6	+0.9	50,584	8.7	7.0	9.6	+2.7	+2.2	+2.4
822	42,041	6.8	7.0	7.9	27,144	5.1	5.3	6.5	-1.7	-1.7	-1.4	50,894	4.8	3.9	6.0	-2.0	-3.1	-1.9
823	43,765	4.5	3.4	7.3	26,090	4.3	4.4	5.4	-0.2	+1.0	-1.9	49,567	6.4	6.7	8.0	+1.9	+3.3	+0.7
824	41,479	5.2	3.7	6.2	25,744	3.0	2.6	4.1	-2.2	-1.1	-2.1	50,809	1.5	2.2	2.2	-3.7	-1.5	-4.0
Average		6.4	5.6	7.8		6.1	6.2	7.5					6.4	5.6	7.9			
Mean Deviation		1.3	1.5	1.4		1.7	1.8	1.9					1.7	1.6	2.2			
Standard Deviation		1.8	1.8	1.9		2.0	2.2	2.4					2.3	1.8	2.8			
Coefficient of Variation		0.28	0.32	0.24		0.33	0.35	0.32					0.36	0.32	0.35			

No.	Fourth-Round Test	Fourth-Round Test, PHS Smoke Opacity, %						Fifth-Round Test	Fifth-Round Test, PHS Smoke Opacity, %					
	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Difference*, Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Difference*, Δ"a"	Δ"b"	Δ"c"
815	63,543	5.4	4.0	6.6	-0.4	-0.7	--	79,564	4.8	4.7	7.0	-1.0	--	+0.4
816	68,070	8.9	7.1	11.0	+2.5	+0.9	+3.7	83,805	8.2	8.6	9.7	+1.8	+2.4	+2.4
817	64,273	1.8**	2.1**	2.4**	-8.4	-5.3	-9.7	78,502	2.1	2.1	2.7	-8.1	-5.3	-9.4
818	60,673	6.8	6.1	8.0	+0.7	-0.3	-0.1	80,158	3.1	3.0	4.0	-3.0	-3.4	-4.1
819	63,798	7.9	6.6	9.0	-0.7	-1.0	-1.4	83,403	2.6	2.6	2.9	-6.0	-5.9	-7.5
820	65,110	5.7	4.8	6.7	+1.1	+1.1	+1.4	80,060	3.9	4.1	5.3	-0.7	-0.4	--
821	66,498	8.3	5.7	11.2	+2.3	+0.9	+4.0	85,517	6.2	5.7	7.0	+0.2	+0.9	-0.2
822	62,929	6.7	5.1	8.8	-0.1	-1.9	+0.9	80,033	2.2	2.9	2.9	-4.6	-4.1	-5.0
823	65,854	7.3	5.2	9.7	+2.8	+1.8	+2.4	80,277	3.9	4.3	6.0	-0.6	+0.9	-1.3
824	60,244	4.8	4.1	5.5	-0.4	+0.4	-0.7	81,701	11.0	11.7	14.6	+5.8	+8.0	+8.4
Average		6.9	5.4	8.5					4.8	5.0	6.2			
Mean Deviation		1.1	0.9	1.4					2.2	2.2	2.7			
Standard Deviation		1.4	1.1	1.9					2.7	2.9	3.5			
Coefficient of Variation		0.20	0.20	0.22					0.57	0.57	0.56			

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*From first-round test.

**Data not included in statistical analysis.

TABLE C-2. TWO-CYCLE ENGINES IN INTERCITY SERVICE

		First-Round Test				Second-Round Test							Third-Round Test							Fourth-Round Test					
		PHS Smoke Opacity, %				PHS Smoke Opacity, %							PHS Smoke Opacity, %							PHS Smoke Opacity, %					
									Difference*,							Difference*,							Difference*,		
No.	Initial Mileage	"a" Factor	"b" Factor	"c" Factor	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
Engine: Detroit Diesel 8V-71N (LSN 65 Injectors) **Vehicle: Truck-Tractor**																									
									Left Engine Bank																
405	8,480	2.4	1.3	5.0	51,510	1.7	0.9	4.6	-0.7	-0.4	-0.4	86,839	5.3	7.2	7.8	+2.9	+5.9	+2.8	124,070	5.8	3.1	13.0	+3.4	+1.8	+8.0
104	5,941	7.4	4.7	13.5	56,915	10.1	4.9	23.3	+2.7	+0.2	+9.8	109,745	17.8	9.3	36.8	+10.4	+4.6	+23.3	170,423	14.1	10.9	27.2	+6.7	+6.2	+13.7
105	5,165	1.5	1.3	5.1	56,320	3.9	1.7	11.6	+2.4	+0.4	+6.5	89,623	8.7	2.7	22.7	+7.2	+1.4	+17.6	139,239	9.7	3.0	23.8	+8.2	+1.7	+18.7
106	6,958	4.6	3.2	8.3	41,529	2.7	1.2	6.7	-1.9	-2.0	-1.6	65,240	8.4	4.1	17.3	+3.8	+0.9	+9.0	122,997	8.4	3.4	21.0	+3.8	+0.2	+12.7
107	12,393	6.9	5.4	11.2	48,657	5.2	3.1	14.0	-1.7	-2.3	+2.8	77,249	3.7	1.6	9.6	-3.2	-3.8	-1.6	124,828	12.7	4.8	30.0	+5.8	-0.6	+18.8
									Right Engine Bank																
405	8,480	2.3	1.6	5.2	51,510	1.7	1.1	4.0	-0.6	-0.5	-1.2	86,839	7.8	5.3	11.3	+5.5	+3.7	+6.1	124,070	4.8	3.2	9.6	+2.5	+1.6	+4.4
104	5,941	4.1	1.6	9.6	56,915	4.8	1.2	14.5	+0.7	-0.4	+4.9	109,745	8.1	2.4	19.8	+4.0	+0.8	+10.2	170,423	7.6	2.4	20.3	+3.5	+0.8	+10.7
105	5,165	1.5	0.9	5.2	56,320	5.2	2.6	12.0	+3.7	+1.7	+6.8	89,623	6.2	4.3	16.8	+4.7	+3.4	+11.6	139,239	11.0	4.6	27.3	+9.5	+3.7	+22.1
106	6,958	4.9	2.6	9.8	41,529	2.5	1.3	6.0	-2.4	-1.3	-3.8	65,240	7.8	3.6	18.0	+2.9	+1.0	+8.2	122,997	10.3	3.6	21.6	+5.4	+1.0	+11.8
107	12,393	4.4	1.4	10.8	48,657	2.4	1.1	8.0	-2.0	-0.3	-2.8	77,249	1.9	0.5	5.2	-2.5	-0.9	-5.6	124,828	7.5	2.0	20.4	+3.1	+0.6	+9.6
Engine: Detroit Diesel 8V-71N (LSN 60 Injectors) **Vehicle: Bus**																									
591	12,894	7.3	4.4	13.7	39,547	11.7	8.1	23.5	+4.4	+3.7	+9.8	79,106	16.5	10.7	29.9	+9.2	+6.3	+16.2	114,566	12.6	9.1	23.1	+5.3	+4.7	+9.4
Average		4.3	2.6	8.9		4.7	2.5	11.7					8.4	4.7	17.7					9.5	4.6	21.6			
Mean Deviation		1.8	1.3	2.8		2.4	1.6	5.3					3.3	2.5	7.0					2.4	2.0	4.3			
Standard Deviation		2.2	1.6	3.2		3.3	2.2	6.5					4.8	3.2	9.1					3.0	2.8	5.7			
Coefficient of Variation		0.	0.61	0.35		0.70	0.88	0.55					0.57	0.70	0.51					0.32	0.61	0.26			

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*From first-round test.

TABLE C-3. DETROIT DIESEL 6V-53N ENGINES IN INTRACITY SERVICE

Engine: Detroit Diesel 6V-53N (LSN 45 Injectors)
Vehicle: Refrigerated Van

		First-Round Test		
		PHS Smoke Opacity, %		
No.	Initial Mileage	"a" Factor	"b" Factor	"c" Factor
3	3,992	8.2	2.3	22.6
4	5,201	15.2	7.6	36.7
8	2,963	5.1	1.3	17.1
10	3,111	7.6	2.9	21.4
16	339	9.4	3.4	29.4
Average		9.1	3.5	25.4
Mean Deviation		2.6	1.6	6.1
Standard Deviation		3.8	2.4	6.9
Coefficient of Variation		0.42	0.69	0.27

		Second-Round Test					
		PHS Smoke Opacity, %					
					Difference*,		
No.	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
3	18,762	29.8	13.9	62.3	+21.6	+11.6	+39.7
4	15,201	8.3	2.8	20.5	-6.9	-4.8	-16.2
8	23,701	22.8	11.1	51.8	+17.7	+9.8	+34.7
10	20,815	20.2	10.8	47.3	+12.8	+7.9	+25.9
16	20,714	26.1	11.1	58.7	+16.7	+7.7	+29.3
Average		21.4	9.9	48.1			
Mean Deviation		5.8	2.9	11.4			
Standard Deviation		8.2	4.2	14.8			
Coefficient of Variation		0.38	0.42	0.30			

		Third-Round Test					
		PHS Smoke Opacity, %					
					Difference*,		
No.	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
3	40,192	20.5	9.2	47.5	+12.3	+6.9	+24.9
4	31,212	30.1	14.1	59.8	+14.9	+6.5	+23.1
8	37,289	17.2	7.8	41.3	+12.1	+6.5	+24.2
10	36,433	16.0	12.5	34.4	+8.4	+9.6	+13.0
16	34,467	27.8	13.6	58.4	+18.4	+10.2	+29.0
Average		22.3	11.4	48.3			
Mean Deviation		5.3	2.4	8.7			
Standard Deviation		6.3	2.8	9.8			
Coefficient of Variation		0.28	0.25	0.20			

		Fourth-Round Test					
		PHS Smoke Opacity, %					
					Difference*,		
No.	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
3	56,169	15.9	7.2	40.2	+7.7	+4.9	+17.6
4	47,566	18.1	7.0	42.7	+2.9	-0.6	+6.0
8	54,481	14.7	6.9	36.3	+9.6	+5.6	+19.2
10	54,724	16.5	11.6	36.9	+9.1	+8.7	+15.5
16	46,174	15.9	7.3	39.4	+6.5	+3.9	+10.0
Average		16.2	8.0	39.1			
Mean Deviation		0.9	1.4	2.0			
Standard Deviation		1.2	2.0	2.3			
Coefficient of Variation		0.07	0.25	0.05			

		Fifth-Round Test					
		PHS Smoke Opacity, %					
					Difference*,		
No.	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
3	76,052	27.3	13.9	56.8	+19.1	+11.6	+34.2
4	74,367	28.7	15.0	58.8	+13.5	+7.4	+22.1
8	87,812	15.8	13.8	30.4	+10.7	+12.5	+13.3
10	76,631	20.6	15.8	43.6	+13.0	+12.9	+22.2
16	73,702	23.1	13.2	47.4	+13.7	+9.8	+18.0
Average		23.1	14.3	47.4			
Mean Deviation		4.0	0.8	8.3			
Standard Deviation		4.7	0.9	10.2			
Coefficient of Variation		0.20	0.06	0.21			

		Sixth-Round Test					
		PHS Smoke Opacity, %					
					Difference*,		
No.	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
3	84,408	15.2	5.3	35.3	+7.0	+3.0	+12.7
4	94,324	24.4	14.2	53.5	+9.2	+6.6	+16.8
8	107,458	Data deleted due to faulty throttle mechanism					
10	88,566	19.2	16.7	28.8	+11.6	+13.8	+7.4
16	89,971	17.4	6.6	39.4	+8.0	+3.2	+10.0
Average		19.1	10.7	30.4			
Mean Deviation		2.8	4.8	9.7			
Standard Deviation		3.4	4.8	5.4			
Coefficient of Variation		0.18	0.45	0.18			

		Seventh-Round Test					
		PHS Smoke Opacity, %					
					Difference*,		
No.	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
3	100,696	20.0	8.6	42.2	+11.8	+6.3	+19.6
4	105,145	47.3	24.5	80.4	+32.1	+16.9	+43.7
8	-	-**	-	-	-	-	-
10	104,235	42.6	21.8	75.3	+35.0	+18.9	+53.9
16	102,677	33.3	12.4	65.1	+23.9	+9.0	+35.7
Average		35.8	16.8	65.8			
Mean Deviation		9.1	6.3	12.1			
Standard Deviation		10.4	6.5	14.7			
Coefficient of Variation		0.29	0.39	0.22			

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*From first-round test.
**Vehicle mileage over 100,000.

TABLE C-4. CUMMINS NH-250 ENGINES IN INTERCITY SERVICE

		First-Round Test				Second-Round Test							Third-Round Test					
		PHS Smoke Opacity, %				PHS Smoke Opacity, %							PHS Smoke Opacity, %					
									Difference*,							Difference*		
No.	Initial Mileage	"a" Factor	"b" Factor	"c" Factor	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
Engine: Cummins NH-250																		
Vehicle: Truck-Tractor																		
21	31,901	17.7	22.4	22.9	18,837	13.8	18.0	18.3	-3.9	-4.4	-4.6	45,585	10.0	15.2	15.6	-7.7	-7.2	-7.3
22	34,842	16.6	16.1	22.5	36,987	18.3	23.7	24.2	+1.7	+7.6	+1.7	58,266	20.5	26.6	27.0	+3.9	+10.5	+4.5
62	32,100	7.3	10.9	11.1	42,104	6.7	10.5	10.7	-0.6	-0.4	-0.4	65,721	7.2	10.6	16.8	-0.1	-0.3	+5.7
15743	54,318	9.5	11.7	11.8	22,334	10.6	14.0	14.7	+1.1	+2.3	+2.9	33,116	14.7	19.1	19.6	+5.2	+7.4	+7.8
15744	56,622	8.4	10.9	11.0	20,632	7.9	13.4	13.7	-0.5	+2.5	+2.7	27,544	14.5	17.8	18.2	+6.1	+6.9	-7.2
15745	58,001	9.9	14.2	14.1	18,710	18.5	21.7	22.5	+8.6	+7.5	+8.4	54,843	20.8	23.4	24.9	+10.9	+9.2	+10.8
15746	40,850	14.7	17.7	19.4	20,916	13.3	17.3	17.7	-1.4	-0.4	-1.7	39,983	14.5	17.1	22.5	-0.2	-0.6	+3.1
24658	12,123	10.6	14.2	14.5	7,045	19.5	25.0	25.4	+8.9	+10.8	+10.9	34,863	13.6	19.6	20.0	+3.0	+5.4	+5.5
26353	239	11.5	16.5	16.6	37,130	14.9	20.1	21.1	+3.4	+3.6	+4.5	55,476	24.9	29.8	30.4	+13.4	+13.3	+13.8
26354	268	8.8	12.6	13.1	39,519	13.4	17.4	17.6	+4.6	+4.8	+4.5	58,893	18.7	25.4	25.8	+9.9	+12.8	+12.7
Average		11.5	14.7	15.7		13.7	18.1	18.6					15.9	20.5	22.1			
Mean Deviation		2.9	2.8	3.7		3.3	3.6	3.8					4.2	4.7	4.0			
Standard Deviation		3.6	3.6	4.3		4.4	4.6	4.5					5.3	5.8	4.6			
Coefficient of Variation		0.31	0.24	0.27		0.32	0.25	0.24					0.33	0.28	0.20			

		Fourth-Round Test							Fifth-Round Test					
		PHS Smoke Opacity, %							PHS Smoke Opacity, %					
					Difference*,							Difference*,		
No.	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
21	76,931	11.4	16.1	16.5	-6.3	-6.3	-6.4							
22	72,726	17.6	23.8	24.1	+1.0	+7.7	+1.6							
62	129,545	13.8	19.3	19.5	+6.5	+8.4	+8.4							
15743	50,401	17.3	19.0	19.6	+7.8	+7.3	+7.8							
15744	50,345	9.9	13.4	13.6	+1.5	+2.5	+2.6							
15745	62,838	27.6	23.8	47.4	+17.7	+9.6	+33.3							
15746	81,572	17.3	18.5	22.5	+2.6	+0.8	+3.1							
24658	69,449	13.4	12.1	18.0	+2.8	+2.1	+3.5	101,198	14.7	12.8	20.7	+4.1	-1.4	+6.2
26353	86,583	22.9	31.5	32.7	+11.4	+15.0	+16.1	122,181	27.6	38.5	38.8	+16.1	+22.0	+22.2
26354	89,732	14.1	19.3	19.4	+5.3	+6.7	+6.3	128,503	17.2	25.0	25.2	+8.4	+12.4	+12.1
Average		16.5	19.7	23.3					19.8	25.4	28.2			
Mean Deviation		4.0	4.0	6.7					5.2	8.7	7.0			
Standard Deviation		5.4	5.6	9.4					5.6	10.5	7.7			
Coefficient of Variation		0.33	0.28	0.40					0.28	0.41	0.27			

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*From first-round test.

TABLE C-5. CUMMINS V-903 ENGINES IN INTERCITY SERVICE

Engine: Cummins V-903
Vehicle: Truck-Tractor

		First-Round Test			Second-Round Test						
		PHS Smoke Opacity, %				PHS Smoke Opacity, %					
									Difference*,		
No.	Initial Mileage	"a" Factor	"b" Factor	"c" Factor	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
966	813	4.3	4.9	6.5	40,214	7.0	7.7	8.2	+2.7	+2.8	+1.7
968	14.709	18.8	18.9	21.2	32,364	12.7	12.3	14.3	-6.1	-6.6	-6.9
970	11,782	8.6	7.9	11.2	31,604	9.8	7.8	12.7	+1.2	-0.1	+1.5
972	13,589	18.2	15.0	22.7	27,244	17.2	17.5	21.3	-1.0	+2.5	-1.4
			(Left Bank)								
415	12,366	3.0	3.4	3.8	63,149	6.2	7.5	5.1	+3.2	+4.1	+1.3
			(Right Bank)								
415	12,366	2.5	3.6	4.5	63,149	6.4	7.9	8.5	+3.9	+4.3	+4.0
Average		9.2	9.0	11.7		9.9	10.1	11.7			
Mean Deviation		6.2	5.4	6.9		3.4	3.2	4.4			
Standard Deviation		7.5	6.5	7.7		4.4	4.1	5.3			
Coefficient of Variation		0.82	0.72	0.65		0.44	0.41	0.44			

		Third-Round Test						Fourth-Round Test						
		PHS Smoke Opacity, %							PHS Smoke Opacity, %					
					Difference*,							Difference*,		
No.	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
966	81,835	7.1	6.2	9.4	+2.8	+1.3	+2.9	121,367	13.4	12.9	17.4	+9.1	+8.0	+10.9
968	112,078	12.6	12.6	16.1	-6.2	-6.3	-5.1	126,120	16.5	18.0	18.1	-2.3	-0.9	-3.1
970	65,441	11.9	12.8	14.9	+3.3	+4.9	+3.7	104,670	13.8	16.2	16.3	+5.2	+8.3	+5.1
972	58,989	11.9	14.1	18.6	-6.3	-0.9	-4.1	98,537	19.7	20.2	21.9	+1.5	+5.2	-0.8
			(Left Bank)											
415	123,883	7.2	7.8	10.9	+4.2	+4.4	+7.1	149,882	8.6	11.4	11.8	+5.6	+8.0	+8.0
			(Right Bank)											
415	123,883	10.4	9.9	12.1	+7.9	+6.3	+7.6	149,882	11.0	12.6	16.3	+8.5	+9.0	+11.8
Average		10.2	10.6	13.7					13.8	15.2	17.0			
Mean Deviation		2.0	2.6	2.9					2.8	2.9	2.2			
Standard Deviation		2.5	3.1	3.2					3.9	3.5	3.0			
Coefficient of Variation		0.24	0.29	0.23					0.28	0.23	0.17			

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*From first-round test.

TABLE C-6. FOUR-CYCLE TURBOCHARGED ENGINES IN INTERCITY SERVICE

		First-Round Test PHS Smoke Opacity, %				Second-Round Test PHS Smoke Opacity, %					
									Difference*,		
No.	Initial Mileage	"a" Factor	"b" Factor	"c" Factor	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
Engine: Mack ENDT 675 **Vehicle:** Truck-Tractor											
1	67,339	26.5	7.6	71.6	42,512	42.2	12.8	89.8	+15.7	+5.2	+18.2
5	70,328	28.7	6.5	74.1	42,955	36.7	13.8	83.7	+8.0	+7.3	+9.6
Average		27.6	7.0	72.9		39.4	13.3	86.8			
Engine: Cummins NTC-335 **Vehicle:** Truck-Tractor											
20	18,665	6.9	3.1	13.5	46,348	15.9	9.1	18.8	+9.0	+6.0	+5.3
144	31,766	7.1	3.5	12.0	55,725	6.4	3.5	15.4	-0.7	-	+3.4
458	87,407	24.6	4.1	54.9	39,365	28.7	5.9	56.8	+4.1	+1.8	+1.9
6213	81,519	9.5	3.7	14.8	32,863	15.4	6.0	17.3	+5.9	+2.3	+2.5
Average		12.0	3.6	23.8		16.6	6.1	27.1			

		Third-Round Test PHS Smoke Opacity, %							Fourth-Round Test PHS Smoke Opacity, %					
					Difference*,							Difference*,		
No.	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
Engine: Mack ENDT 675 **Vehicle:** Truck-Tractor														
1	84,011	30.0	12.9	80.8	+3.5	+5.3	+9.2	137,771	44.7	13.6	86.9	+18.2	+6.0	+15.3
5	82,841	31.6	9.2	66.8	+2.9	+2.7	-7.3	124,455	36.8	10.5	80.3	+8.1	+4.0	+6.2
Average		30.8	11.0	73.8					40.8	12.0	83.6			
Engine: Cummins NTC-335 **Vehicle:** Truck-Tractor														
20	88,269	15.7	7.3	19.8	+8.8	+4.2	+6.3	109,998	14.4	6.4	21.3	+7.5	+3.3	+7.8
144	-	-**	-	-	-	-	-	-	-	-	-	-	-	-
458	85,697	16.8	4.9	33.0	-7.8	+0.8	-21.9	131,872	17.2	6.3	35.3	-7.4	+2.2	-19.6
6213	74,051	11.9	6.3	16.6	+2.4	+2.6	+1.8	96,226	10.1	7.3	13.7	+0.6	+3.6	-1.1
Average		14.8	6.2	23.1					13.9	6.7	23.4			

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*From first-round test.

**Vehicle deleted from test fleet.

TABLE C-7. FOUR-CYCLE TURBOCHARGED ENGINES IN INTRACITY SERVICE

		First-Round Test				Second-Round Test							Third-Round Test							Fourth-Round Test					
		PHS Smoke Opacity, %				PHS Smoke Opacity, %							PHS Smoke Opacity, %							PHS Smoke Opacity, %					
									Difference*,							Difference*,							Difference*,		
No.	Initial Mileage	"a" Factor	"b" Factor	"c" Factor	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
Engine: Mack ENDT 675 **Vehicle: Commercial Garbage Truck**																									
2	1,454	17.2	6.0	48.4	12,608	32.2	11.1	71.4	+15.0	+5.1	+23.0	25,587	36.9	14.4	81.7	+19.7	+8.4	+33.3	41,513	28.3	13.3	61.2	+11.1	+7.3	+12.8
3	28,574	20.1	9.4	48.6	12,180	23.7	9.6	53.4	+3.6	+0.2	+4.8	26,252	41.8	16.0	73.4	+21.7	+6.6	+24.8	42,858	29.3	11.4	63.1	+9.2	+2.0	+14.5
4	1,505	25.6	12.0	59.2	3,131	22.4	7.8	63.8	-3.2	-4.2	+4.6	17,071	33.8	13.3	78.8	+8.2	+1.3	+19.6	30,847	29.8	10.8	73.8	+4.2	-1.2	+14.6
5	5,045	14.8	4.1	37.6	6,357	27.2	10.8	68.0	+12.4	-6.7	+30.4	22,672	29.8	7.4	66.1	+15.0	+3.3	+28.5	30,012	27.4	12.6	59.2	+12.6	+8.5	+21.6
6	1,510	18.1	5.4	48.4	9,746	29.5	11.0	66.1	+11.4	+5.6	+17.7	24,056	44.0	18.3	79.8	+25.9	+12.9	+31.4	44,056	25.2	9.5	61.5	+7.1	+4.1	+13.1
Average		19.2	7.4	48.4		27.0	10.1	64.5					37.3	13.9	76.0					28.0	11.5	63.8			
Mean Deviation		3.0	2.7	4.4		3.2	1.1	4.8					4.5	2.8	5.0					1.4	1.1	4.0			
Standard Deviation		4.1	3.2	6.8		4.0	1.4	6.0					5.8	4.1	5.6					1.8	1.5	5.2			
Coefficient of Variation		0.21	0.43	0.14		0.15	0.14	0.09					0.16	0.29	0.07					0.06	0.13	0.08			
Engine: Mack ENDT 673B **Vehicle: Truck-Tractor**																									
60122	6,306	15.2	7.4	22.7	4,184	17.4	12.8	25.0	+2.2	+5.4	+2.3	7,106	22.6	14.0	31.3	+7.4	+6.6	+8.6	10,735	22.0	14.9	35.1	+6.8	+7.5	+12.4
60124	4,838	7.7	6.5	9.7	4,148	10.5	9.7	15.7	+2.8	+3.2	+6.0	8,058	14.1	8.5	18.5	+6.4	+2.0	+8.8	11,975	14.3	12.0	20.4	+6.6	+5.5	+10.7
Average		11.4	7.0	16.2		14.0	11.2	20.4					18.4	11.2	24.9					18.2	13.4	27.8			

		Fifth-Round Test							Sixth-Round Test							Seventh-Round Test					
		PHS Smoke Opacity, %							PHS Smoke Opacity, %							PHS Smoke Opacity, %					
					Difference*,							Difference*,							Difference*,		
No.	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
Engine: Mack ENDT 675 **Vehicle: Commercial Garbage Truck**																					
2	-	-**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	55,584	40.9	18.6	53.7	+20.8	+9.2	+5.1	67,092	40.2	18.2	79.2	+20.1	+8.8	+30.6	71,861	62.3	31.3	93.0	+42.2	+21.9	+44.4
4	45,066	55.5	28.6	96.5	+29.9	+16.6	+37.3	63,707	47.3	15.3	92.6	+21.7	+3.3	+33.3	73,132	51.3	22.6	93.1	+25.7	+10.6	+33.9
5	45,487	38.5	9.9	83.2	+23.7	+5.8	+45.6	57,883	28.5	7.9	69.3	+13.7	+3.8	+31.7	Wrecked						
6	57,451	33.9	10.6	71.1	+15.8	+1.2	+22.7	74,885	47.9	24.3	85.4	+29.8	+18.9	+37.0	84,480	53.9	20.8	91.4	+35.8	+15.4	+43.0
Average		42.2	16.9	76.1					41.0	16.4	81.6					55.8	24.9	92.5			
Mean Deviation		6.6	6.7	13.7					6.6	4.8	7.8										
Standard Deviation		8.1	7.6	15.8					7.8	5.9	8.6										
Coefficient of Variation		0.19	0.45	0.20					0.19	0.35	0.10										
Engine: Mack ENDT 673B **Vehicle: Truck-Tractor**																					
60122	15,744	28.3	13.5	42.4	+13.1	+6.1	+19.7	21,269	26.5	13.2	41.9	+11.3	+5.8	+19.2	27,546	26.4	20.2	36.2	+11.2	+12.8	-2.7
60124	17,338	17.4	10.2	21.9	+9.7	+3.7	+12.2	19,975	13.7	9.4	18.9	+6.0	+2.9	+9.2	26,965	14.2	7.0	20.0	+6.5	+0.5	+26.5
Average		22.8	11.8	32.2					20.1	11.3	30.4					20.3	13.6	28.1			

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*From first-round test.

**Vehicle deleted from test fleet.

TABLE C-8. CATERPILLAR 1145 ENGINES IN INTRACITY SERVICE

Engine: Caterpillar 1145
Vehicle: Truck

No.	Initial Mileage	First-Round Test PHS Smoke Opacity, % "a" Factor	"b" Factor	"c" Factor
507	4,493	13.0	8.5	32.7
510	3,950	15.4	11.2	32.9
512	2,387	13.8	14.9	28.0
519	5,831	16.2	10.3	39.7
527	2,022	14.9	9.1	40.0
Average		14.6	10.7	34.7
Mean Deviation		1.0	1.7	4.2
Standard Deviation		1.3	2.4	4.6
Coefficient of Variation		0.09	0.22	0.13

No.	Second-Round Test Elapsed Test Miles	PHS Smoke Opacity, % "a" Factor	"b" Factor	"c" Factor	Difference*, Δ"a"	Δ"b"	Δ"c"
507	2,729	14.9	15.2	25.0	+1.9	+6.7	-7.7
510	2,272	12.7	13.5	22.9	-2.7	+2.3	-10.0
512	1,051	20.7	17.0	41.9	+6.9	+2.5	+13.9
519	11,202	16.6	14.6	33.8	0.4	+4.3	-5.9
527	1,984	19.8	17.3	43.5	+5.3	+8.2	+3.5
Average		16.9	15.5	33.4			
Mean Deviation		2.6	1.3	7.6			
Standard Deviation		3.3	1.6	8.4			
Coefficient of Variation		0.20	0.10	0.25			

No.	Third-Round Test Elapsed Test Miles	PHS Smoke Opacity, % "a" Factor	"b" Factor	"c" Factor	Difference*, Δ"a"	Δ"b"	Δ"c"
507	6,603	27.5	25.3	50.8	+14.5	+16.8	+18.1
510	4,719	19.4	19.1	38.1	+4.0	+7.9	+5.2
512	2,941	22.6	23.2	37.9	+8.8	+8.7	+9.9
519	20,788	20.7	18.6	36.9	+4.5	+8.3	-2.8
527	3,966	20.1	19.5	39.4	+5.6	+10.4	-0.6
Average		22.1	21.1	40.6			
Mean Deviation		2.4	2.5	4.1			
Standard Deviation		3.3	3.0	5.2			
Coefficient of Variation		0.15	0.14	0.12			

No.	Fourth-Round Test Elapsed Test Miles	PHS Smoke Opacity, % "a" Factor	"b" Factor	"c" Factor	Difference*, Δ"a"	Δ"b"	Δ"c"
507	9,908	29.6	33.4	48.0	+16.6	+24.9	+15.3
510	7,108	22.8	21.6	46.7	+7.4	+10.4	+13.8
512	3,021	29.4	30.5	40.5	+15.6	+16.0	+12.5
519	25,738	23.2	22.1	44.6	+7.0	+11.8	+4.9
527	5,933	18.4	19.6	36.9	+3.9	+10.5	-3.1
Average		24.7	25.4	43.3			
Mean Deviation		3.9	5.2	3.7			
Standard Deviation		4.8	6.1	4.1			
Coefficient of Variation		0.19	0.24	0.09			

No.	Fifth-Round Test Elapsed Test Miles	PHS Smoke Opacity, % "a" Factor	"b" Factor	"c" Factor	Difference*, Δ"a"	Δ"b"	Δ"c"
507	13,273	27.0	21.4	59.2	+14.0	+12.9	+26.5
510	9,937	21.4	18.3	45.4	+6.0	+7.1	+12.5
512	7,431	27.2	19.2	42.7	+13.4	+4.7	+14.7
519	35,392	24.9	22.8	47.9	+8.7	+12.5	+8.2
527	9,473	15.4	10.8	41.9	+0.9	+1.7	+1.9
Average		23.2	18.5	47.4			
Mean Deviation		3.8	3.2	4.9			
Standard Deviation		4.9	4.7	6.3			
Coefficient of Variation		0.21	0.25	0.13			

No.	Sixth-Round Test Elapsed Test Miles	PHS Smoke Opacity, % "a" Factor	"b" Factor	"c" Factor	Difference*, Δ"a"	Δ"b"	Δ"c"
507	17,437	29.9	24.7	64.5	+16.9	+16.2	+31.8
510	13,211	28.3	22.4	54.9	+12.9	+11.2	+22.0
512	9,956	24.5	12.3	57.4	+10.7	-2.2	+29.4
519	48,337	37.0	35.9	59.6	+20.8	+25.6	+19.9
527	12,293	13.1	12.2	22.2	-1.4	+3.1	-17.8
Average		26.6	21.5	51.7			
Mean Deviation		6.2	7.4	11.8			
Standard Deviation		7.9	8.8	15.1			
Coefficient of Variation		0.30	0.41	0.29			

No.	Seventh-Round Test Elapsed Test Miles	PHS Smoke Opacity, % "a" Factor	"b" Factor	"c" Factor	Difference*, Δ"a"	Δ"b"	Δ"c"
507	22,994	21.3	17.6	48.4	+8.3	+9.1	+15.7
510	18,508	19.7	19.4	44.1	+4.3	+8.2	+11.2
512	14,594	20.4	14.4	46.7	+6.6	-0.1	+18.7
519	61,666	21.0	19.7	37.3	+4.8	+9.4	-2.4
527	18,749	18.3	16.7	31.0	+3.8	+7.6	-9.0
Average		20.0	17.6	41.5			
Mean Deviation		0.9	1.6	5.9			
Standard Deviation		1.1	1.9	6.5			
Coefficient of Variation		0.05	0.11	0.15			

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*From first-round test.

TABLE C-9. CATERPILLAR 1150 ENGINES IN INTRACITY SERVICE

Engine: Caterpillar 1150
Vehicle: Truck-Tractor

		First-Round Test				Second-Round Test							Third-Round Test							Fourth-Round Test					
		PHS Smoke Opacity, %				PHS Smoke Opacity, %							PHS Smoke Opacity, %							PHS Smoke Opacity, %					
									Difference*,							Difference*,							Difference*,		
No.	Initial Mileage	"a" Factor	"b" Factor	"c" Factor	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
880	13,140	25.7	15.6	69.5	3,016	15.2	8.8	45.4	-10.5	-6.8	-24.1	6,341	14.2	14.0	31.5	-11.5	-1.6	-38.0	9,224	23.0	21.0	58.6	-2.7	+5.4	-10.9
881	8,226	18.1	9.6	56.7	3,555	15.9	13.4	45.4	-2.2	+3.8	-11.3	6,569	15.2	16.5	36.5	-2.9	+6.9	-20.2	9,618	20.1	17.4	48.7	+2.0	+7.8	-8.0
883	7,721	17.0	7.0	58.0	3,079	15.8	10.5	50.2	-1.2	+3.5	-7.8	5,879	17.7	11.9	52.1	+0.7	+4.9	-5.9	9,191	16.5	19.7	37.3	-0.5	+12.7	-20.7
884	7,650	17.5	9.6	54.1	13,995	17.5	11.9	45.1	--	+2.3	-9.0	17,051	19.5	17.2	50.8	+2.0	+7.6	-3.3	19,312	25.4	22.3	66.2	+7.9	+12.7	+12.1
885	8,871	19.5	8.1	51.7	3,881	17.7	11.0	58.8	+2.2	+2.9	+7.1	6,530	16.4	13.8	41.9	+0.9	+5.7	-9.8	9,669	20.1	13.7	52.3	+4.6	+5.6	+0.6
Average		18.8	10.0	58.0		16.4	11.1	49.0					16.6	14.7	42.6					21.0	18.8	52.6			
Mean Deviation		2.8	2.3	4.6		0.9	1.2	4.4					1.6	1.7	7.1					2.5	2.6	7.8			
Standard Deviation		4.0	3.3	6.1		1.1	1.7	5.3					2.1	2.2	8.0					3.4	3.4	9.1			
Coefficient of Variation		0.21	0.33	0.10		0.07	0.15	0.10					0.13	0.15	0.18					0.16	0.18	0.17			

		Fifth-Round Test						Sixth-Round Test							Seventh-Round Test						
		PHS Smoke Opacity, %							PHS Smoke Opacity, %							PHS Smoke Opacity, %					
					Difference*,							Difference*,							Difference*,		
No.	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
880	12,679	25.1	24.9	57.0	-0.6	+9.3	-12.5	15,601	20.0	22.7	45.7	-5.7	+7.1	-23.8	20,138	25.8	19.4	63.6	+0.1	+3.8	-5.9
881	13,015	23.8	23.2	53.4	+5.7	+13.6	-3.3	15,721	22.6	21.7	53.7	+4.5	+12.1	-3.0	19,918	29.7	22.5	71.1	+11.6	+12.9	+14.4
883	12,565	22.2	14.2	58.2	+5.2	+7.2	+0.2	15,612	23.1	25.8	55.4	+6.1	+18.8	-2.6	19,722	19.8	16.4	47.1	+2.8	+9.4	-10.9
884	22,346	27.8	25.6	64.8	+10.3	+16.0	+10.7	25,680	28.2	30.3	61.1	+10.7	+20.7	+7.0	29,696	23.2	24.2	51.3	+5.7	+16.6	-2.8
885	13,216	29.5	19.3	73.6	+14.0	+11.2	+21.9	16,010	20.0	17.2	65.0	+4.5	+9.1	-6.7	20,632	19.1	12.6	47.6	+3.6	+4.5	-4.1
Average		25.7	21.4	61.4					22.8	23.5	52.2					23.5	19.0	56.1			
Mean Deviation		2.3	3.8	6.2					2.3	3.6	5.5					3.4	3.6	9.0			
Standard Deviation		2.9	4.7	7.1					3.0	4.4	6.1					3.9	4.2	9.6			
Coefficient of Variation		0.11	0.22	0.11					0.13	0.19	0.11					0.17	0.22	0.17			

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*From first-round test.

TABLE C-10. GM DH 478 AND IHC 550B ENGINES IN INTRACITY SERVICE

		First-Round Test				Second-Round Test							Third-Round Test							Fourth-Round Test					
		PHS Smoke Opacity, %				PHS Smoke Opacity, %							PHS Smoke Opacity, %							PHS Smoke Opacity, %					
									Difference*,							Difference*,							Difference*,		
No.	Initial Mileage	"a" Factor	"b" Factor	"c" Factor	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
Engine: GM DH 478																									
Vehicle Truck-Tractor																									
118	5,285	8.4	10.1	10.3	3,293	12.6	13.0	15.3	+4.2	+2.9	+5.0	6,322	15.7	20.0	20.3	+7.3	+9.9	+10.0	9,605	13.2	19.2	19.5	+4.8	+9.1	+9.2
133	7,134	6.8	8.8	9.5	3,468	8.7	12.0	12.5	+1.9	+3.2	+3.0	7,733	10.2	16.3	16.9	+3.4	+7.5	+7.4	10,919	8.6	12.1	12.3	+1.8	+3.3	+2.8
137	762	5.1	6.5	6.7	2,082	7.6	8.6	58.2	+2.5	+2.1	+51.5	4,475	24.2	32.6	39.1	+19.1	+26.1	+32.4	7,082	24.0	28.5	33.8	+18.9	+22.0	+27.1
190	970	8.9	11.6	11.7	3,230	15.1	18.4	18.6	+6.2	+6.8	+6.9	4,966	16.7	20.7	21.7	+7.8	+9.1	+10.0	7,464	10.6	14.3	13.6	+1.7	+2.7	+1.9
Average		7.3	9.2	9.6		11.0	13.0	26.2					16.7	22.4	[illegible]					14.1	18.5	19.8			
Mean Deviation		1.4	1.6	1.5		2.8	2.7	16.1					3.8	5.1	7.3					5.0	5.3	7.0			
Standard Deviation		1.7	2.2	1.8		3.5	4.1	18.6					5.8	7.1	8.6					6.9	7.3	8.5			
Coefficient of Variation		0.23	0.24	0.18		0.32	0.32	0.70					0.35	0.32	0.35					0.49	0.39	0.43			
Engine: International Harvester DV 550B																									
Vehicle: Dump Truck																									
631	10,029	15.9	17.9	27.6	7,626	17.9	18.8	31.3	+2.0	+0.9	+3.7	13,896	26.4	27.4	38.5	+10.5	+9.5	+10.9	20,551	22.4	30.3	36.5	+6.5	+12.4	+8.9

		Fifth-Round Test							Sixth-Round Test							Seventh-Round Test					
		PHS Smoke Opacity, %							PHS Smoke Opacity, %							PHS Smoke Opacity, %					
					Difference*,							Difference*,							Difference*,		
No.	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"	Elapsed Test Miles	"a" Factor	"b" Factor	"c" Factor	Δ"a"	Δ"b"	Δ"c"
Engine: GM DH 478																					
Vehicle: Truck-Tractor																					
118	13,117	17.7	22.5	24.0	+9.3	+12.4	+13.7	16,673	15.5	18.4	18.7	+7.1	+8.3	+8.4	22,999	15.6	18.2	18.8	+7.2	+8.1	+8.5
133	16,606	11.7	13.7	14.4	+4.9	+4.9	+4.9	26,775	8.0	10.8	11.1	+1.2	+2.0	+1.6	35,971	11.0	12.0	12.7	+4.2	+3.2	+3.2
137	9,806	20.6	25.8	30.1	+15.5	+19.3	+23.4	14,013	22.9	26.5	30.7	+17.8	+20.0	+24.0	22,315	26.4	29.4	33.7	+21.3	+22.9	+27.0
190	9,473	16.4	18.4	20.6	+7.5	+6.8	+8.9	16,869	17.2	19.3	19.5	+8.3	+7.7	+7.8	21,877	17.7	21.5	21.9	+8.8	+9.9	+10.2
Average		16.6	20.1	22.3					15.9	18.8	20.0					17.7	20.3	21.8			
Mean Deviation		2.6	4.0	4.8					4.2	4.2	5.4					4.4	5.2	6.0			
Standard Deviation		3.7	5.2	5.7					5.3	5.6	7.0					5.6	6.3	7.6			
Coefficient of Variation		0.22	0.26	0.25					0.33	0.30	0.34					0.32	0.31	0.35			
Engine: International Harvester DV 550B																					
Vehicle: Dump Truck																					
631	27,749	26.7	28.5	36.6	+10.8	+10.6	+9.0	34,950	18.9	14.9	36.8	+3.0	-3.0	+9.2	39,379	18.5	20.2	30.6	+2.6	+2.3	+3.0

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*From first-round test.

APPENDIX D

CHASSIS SIMULATED FEDERAL SMOKE TEST

"a", "b", and "c" Factors as a
Function of Odometer Miles

Individual Graphs

All Trucks, All Tests

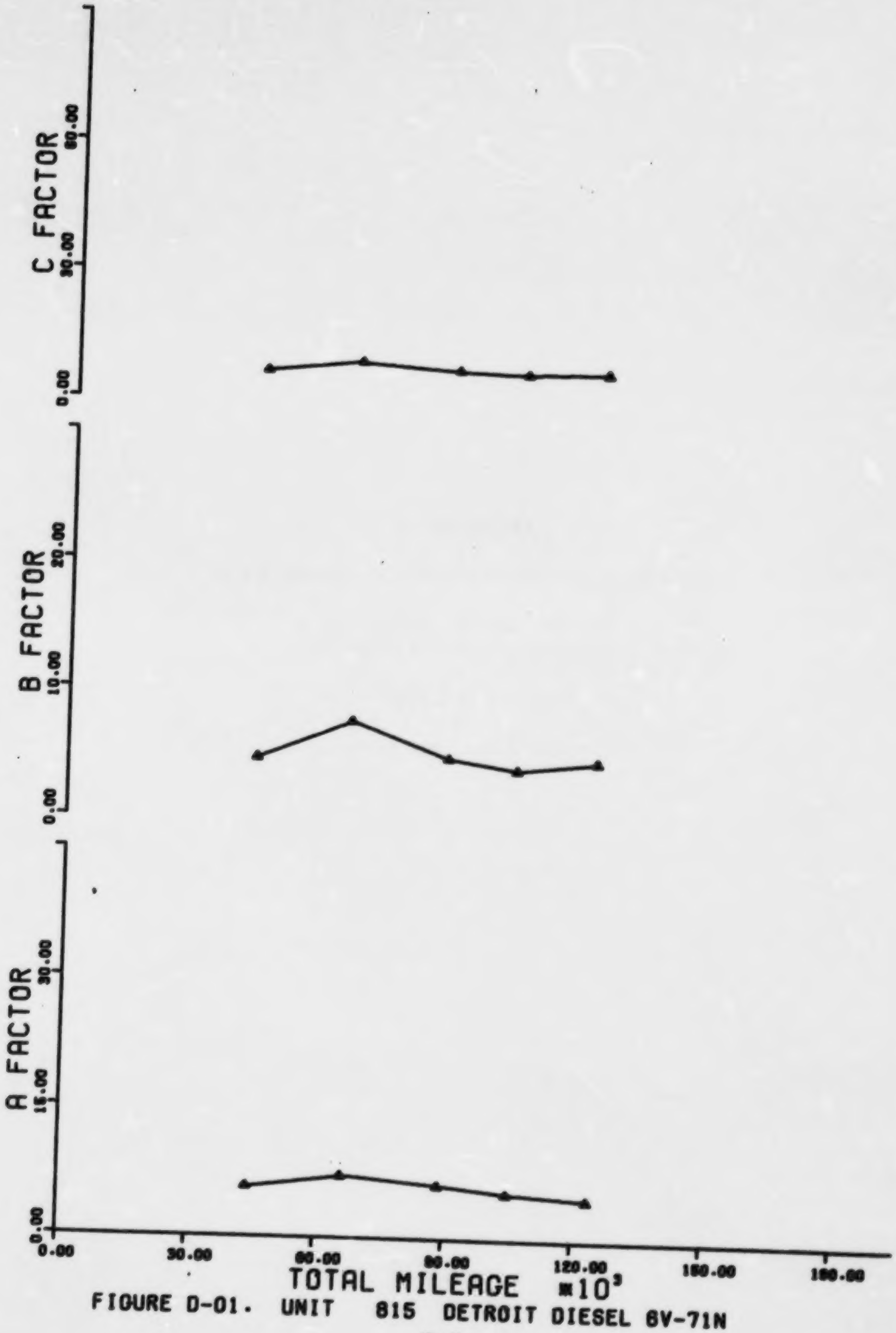

FIGURE D-01. UNIT 815 DETROIT DIESEL 6V-71N

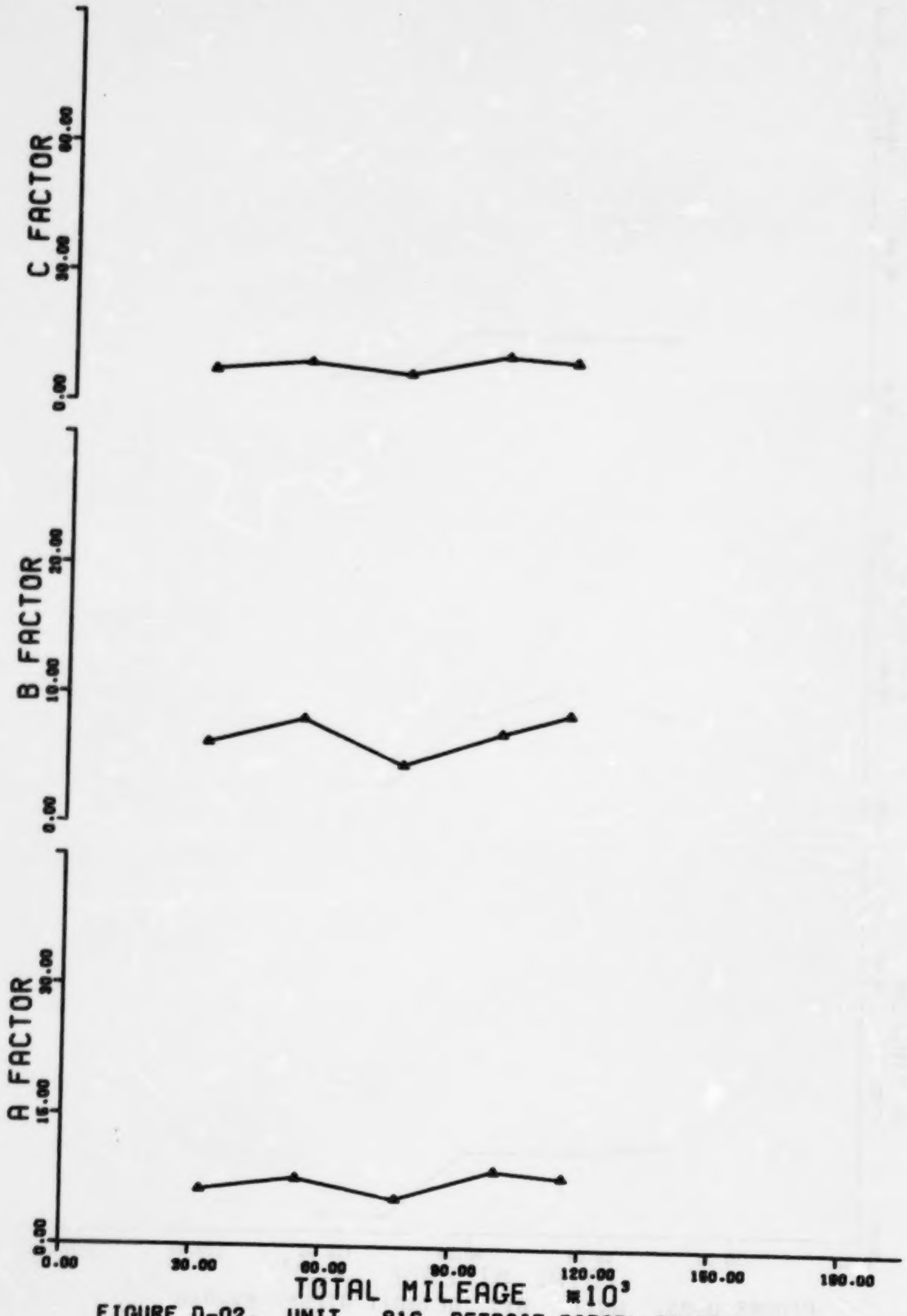

FIGURE D-02. UNIT 816 DETROIT DIESEL 6V-71N

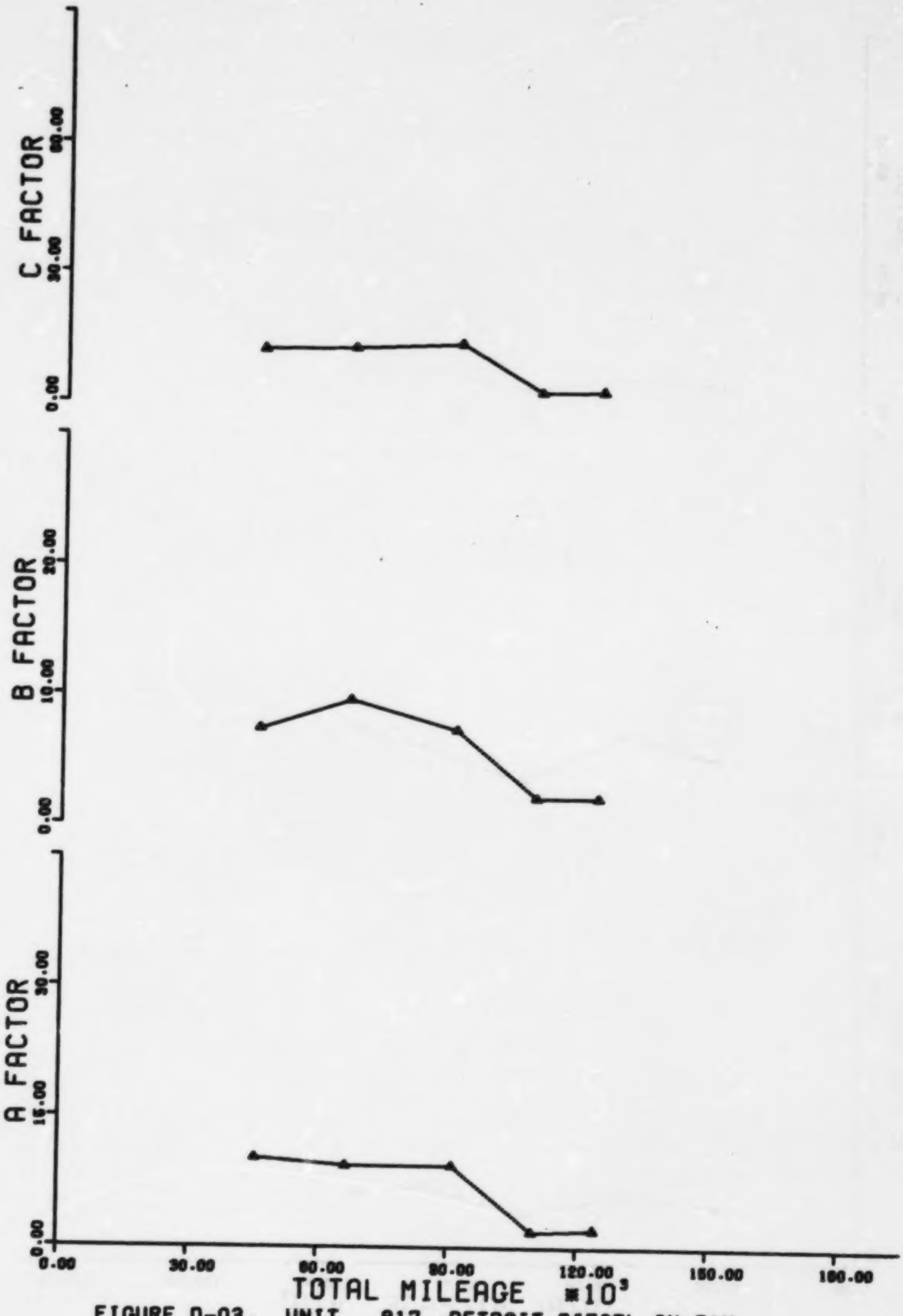

FIGURE D-03. UNIT 817 DETROIT DIESEL 6V-71N

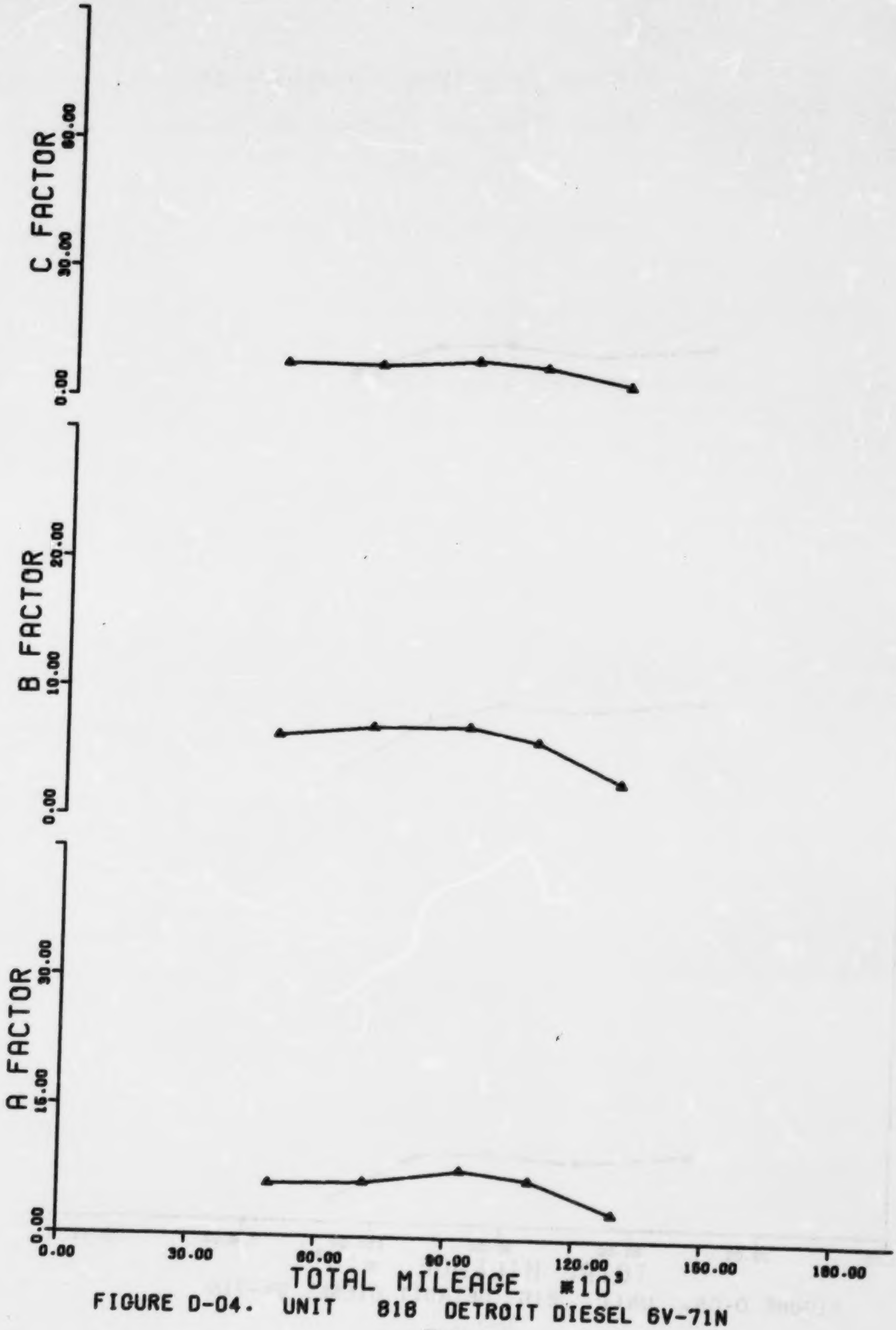

FIGURE D-04. UNIT 818 DETROIT DIESEL 6V-71N

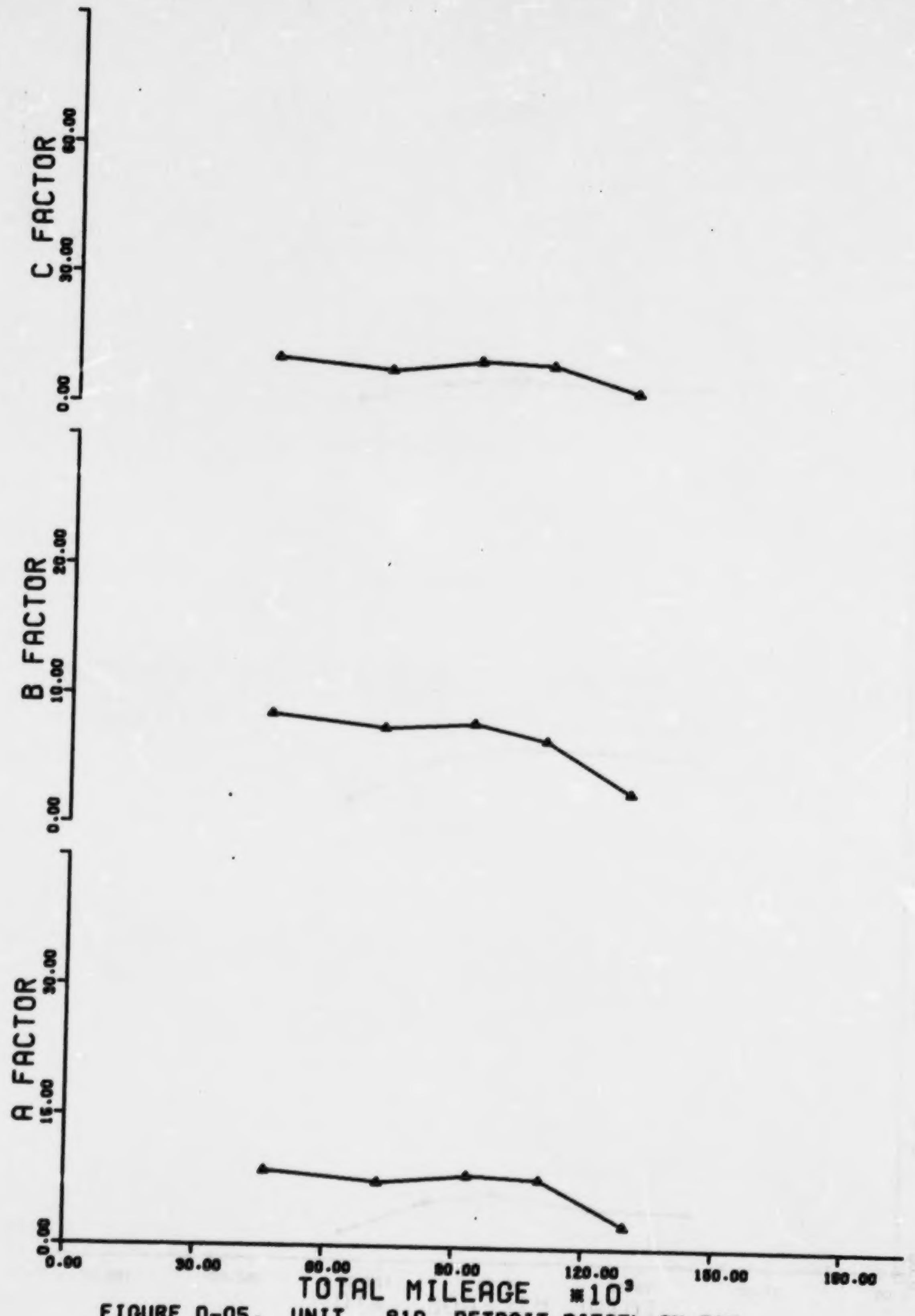

FIGURE D-05. UNIT 819 DETROIT DIESEL 6V-71N

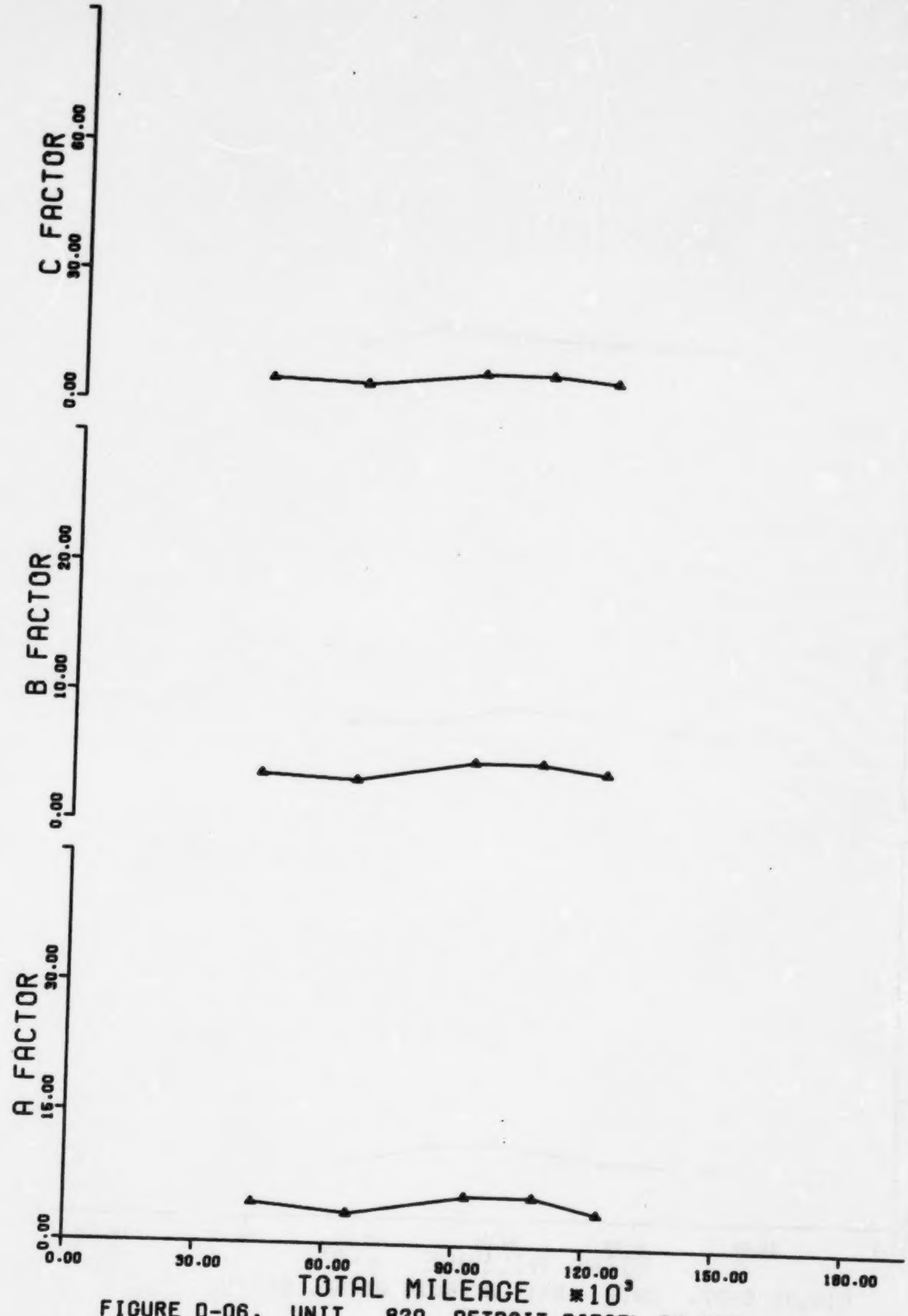

FIGURE D-06. UNIT 820 DETROIT DIESEL 6V-71N

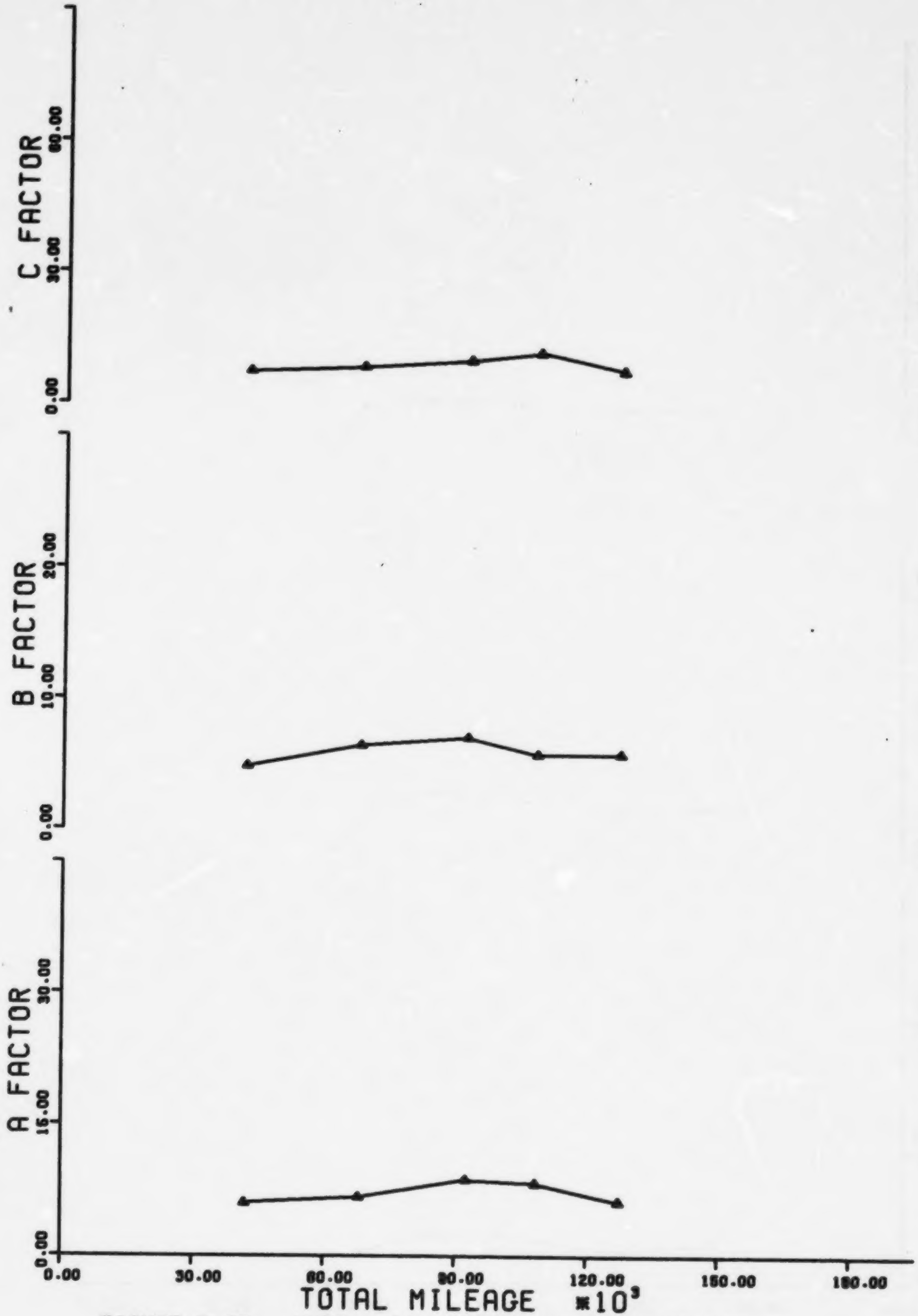

FIGURE D-07. UNIT 821 DETROIT DIESEL 6V-71N

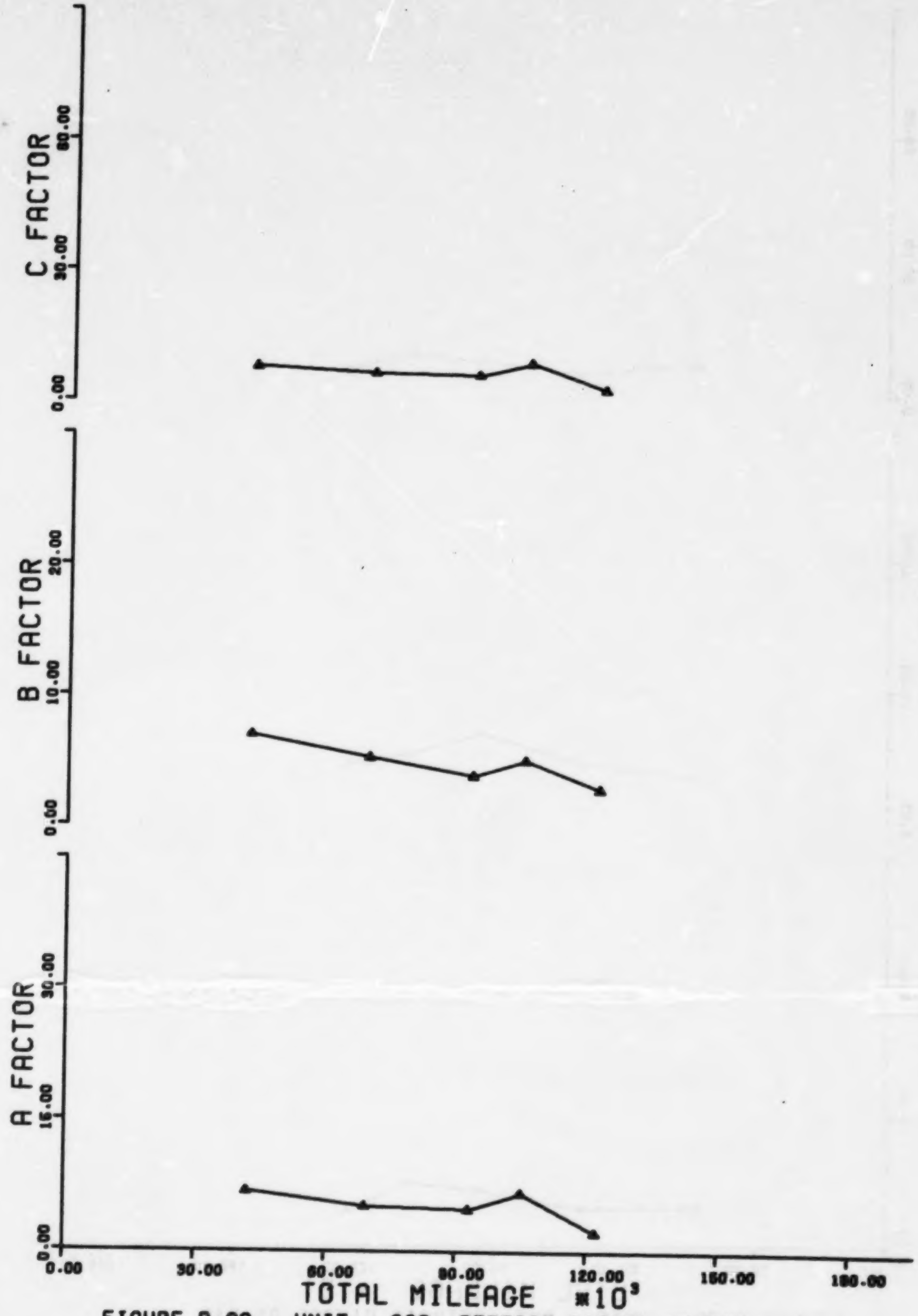

FIGURE D-08. UNIT 822 DETROIT DIESEL 6V-71N

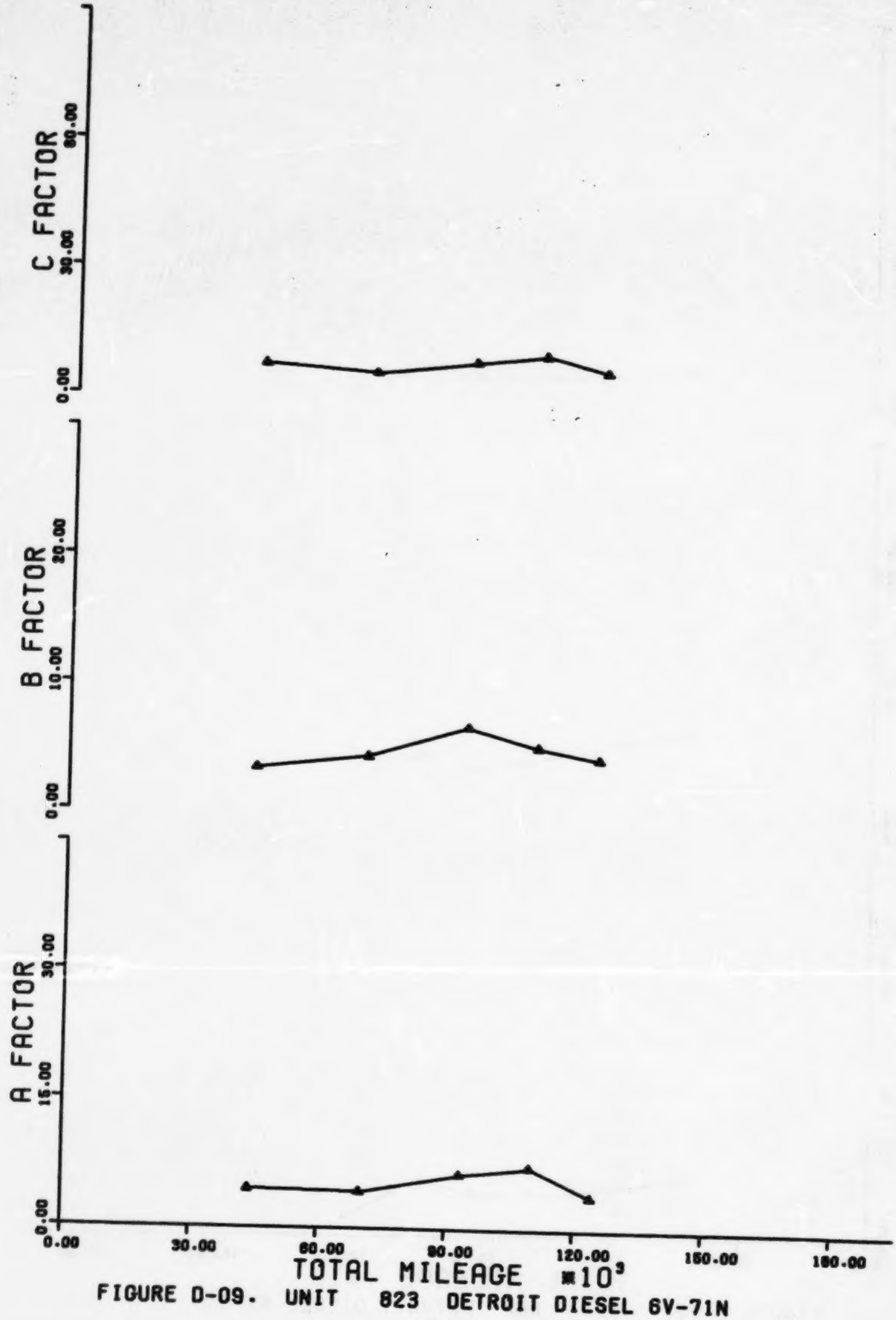

FIGURE D-09. UNIT 823 DETROIT DIESEL 6V-71N

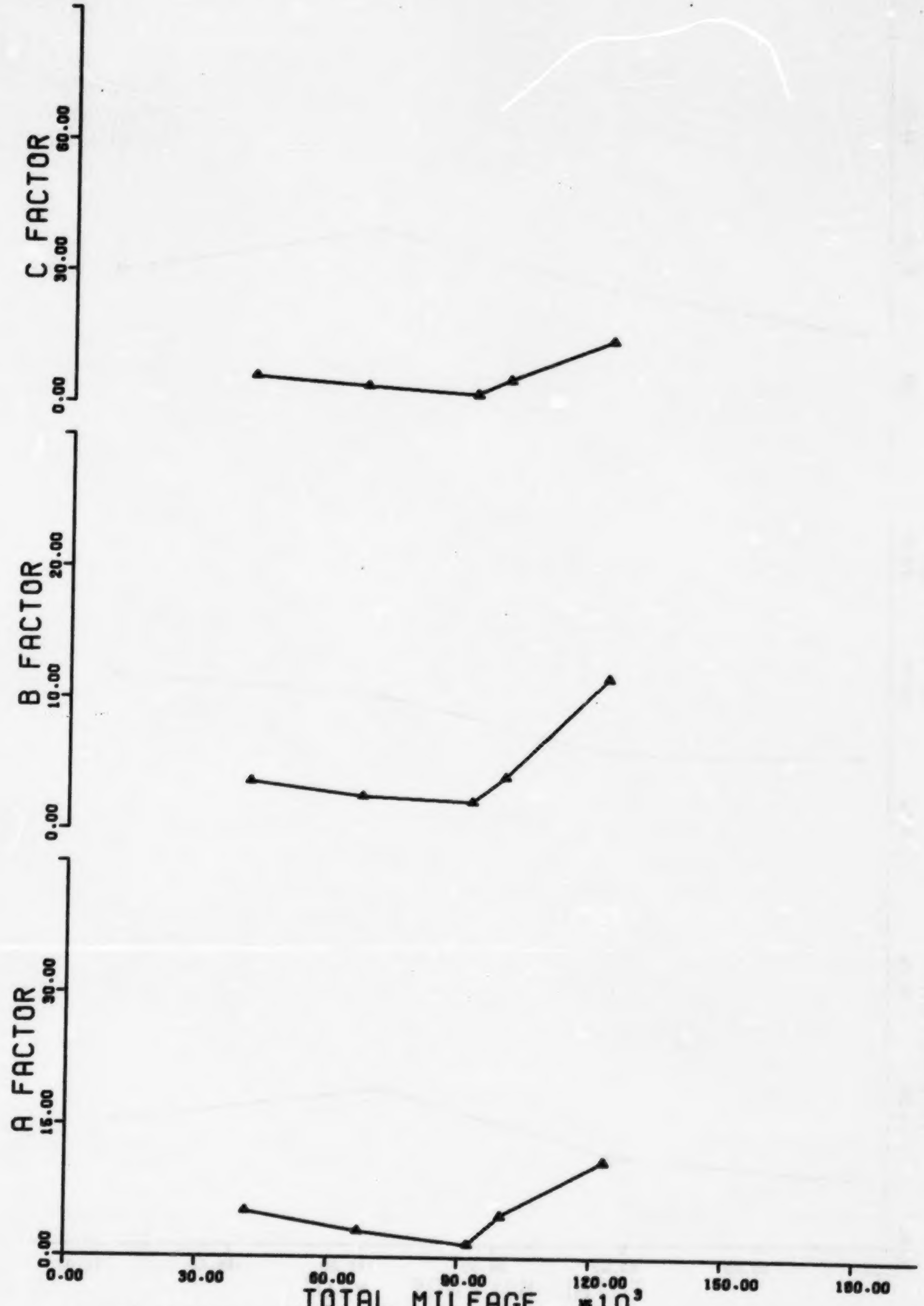

FIGURE D-10. UNIT 824 DETROIT DIESEL 6V-71N

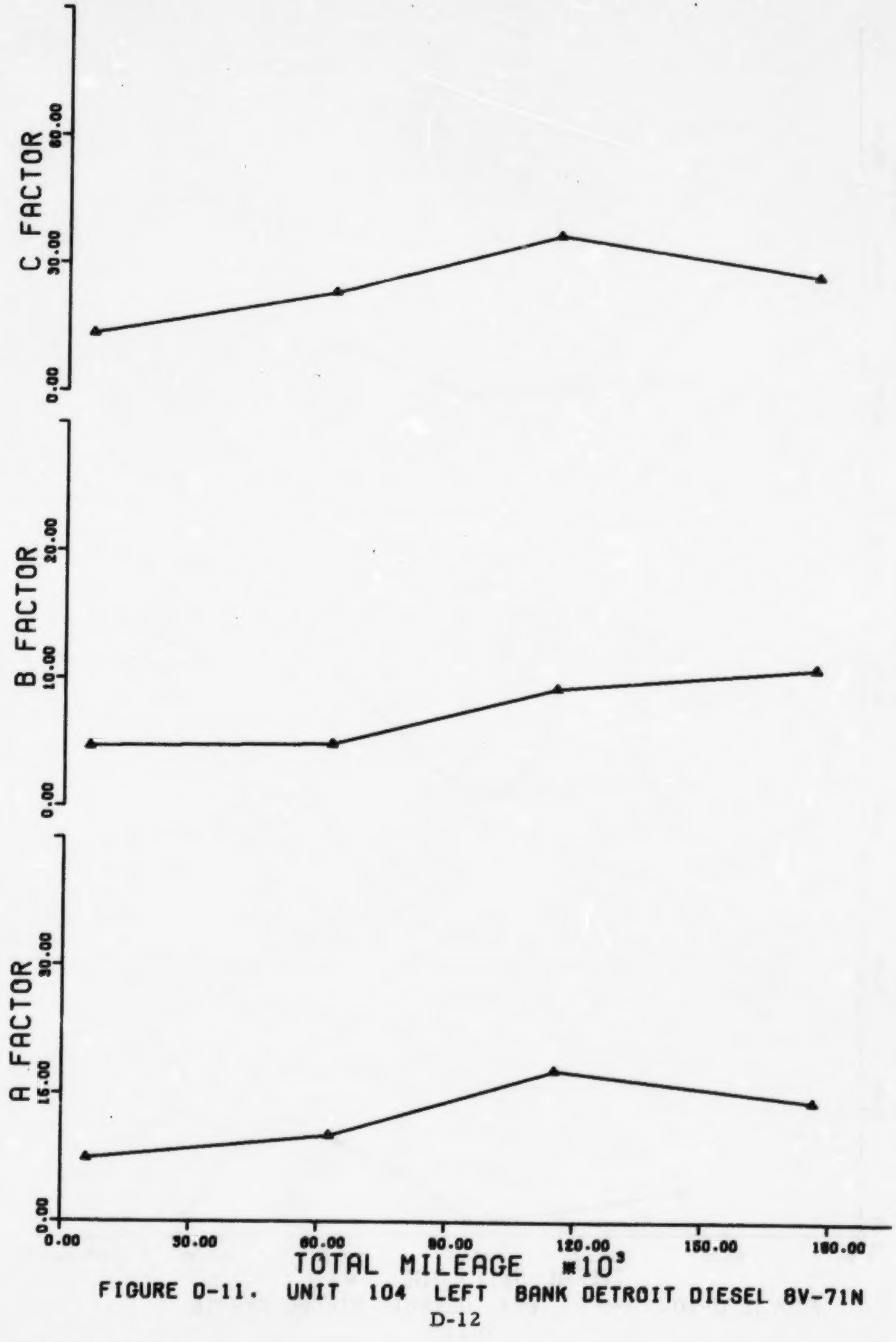

FIGURE D-11. UNIT 104 LEFT BANK DETROIT DIESEL 8V-71N

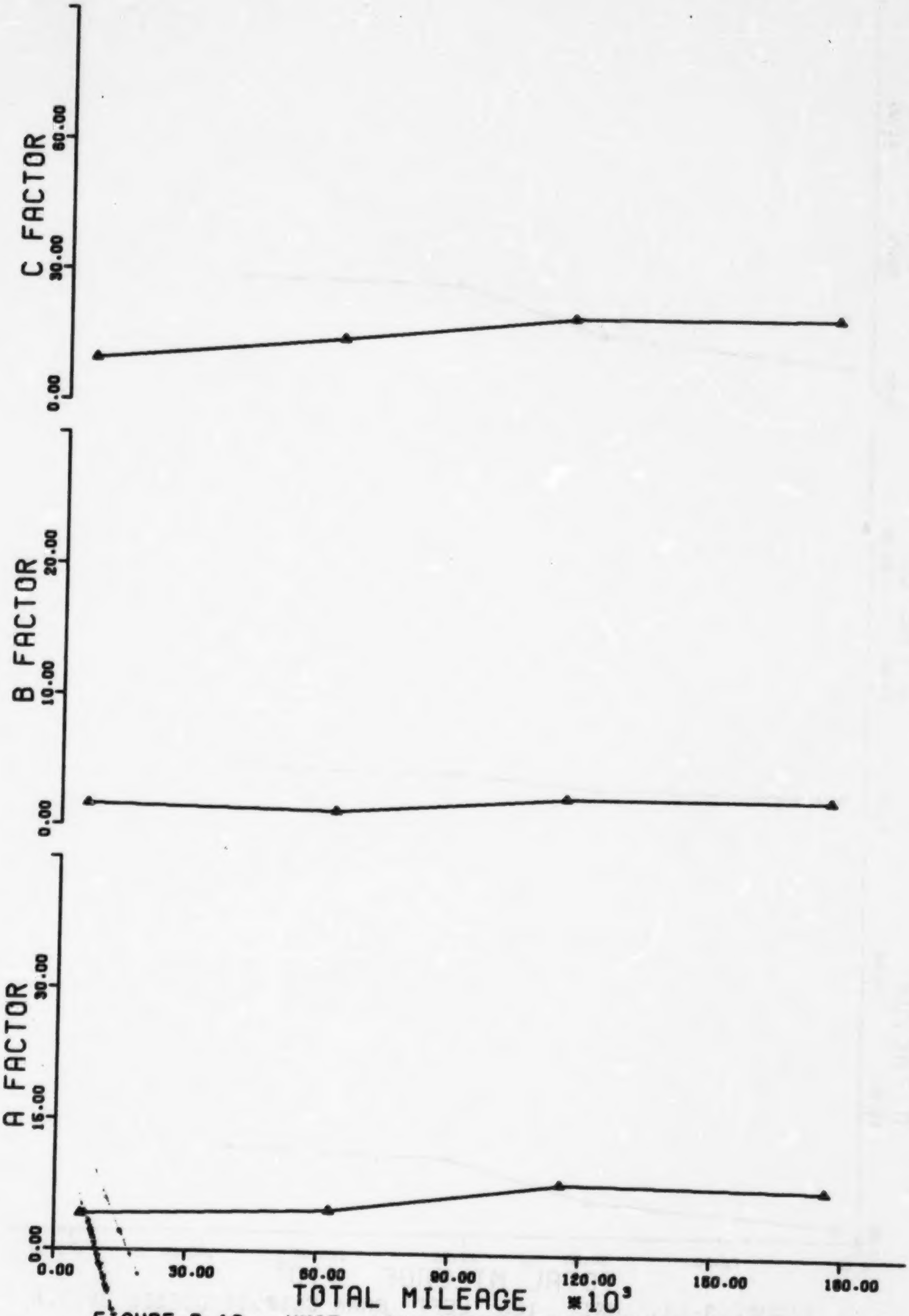

FIGURE D-12. UNIT 104 RIGHT BANK DETROIT DIESEL 8V-71N

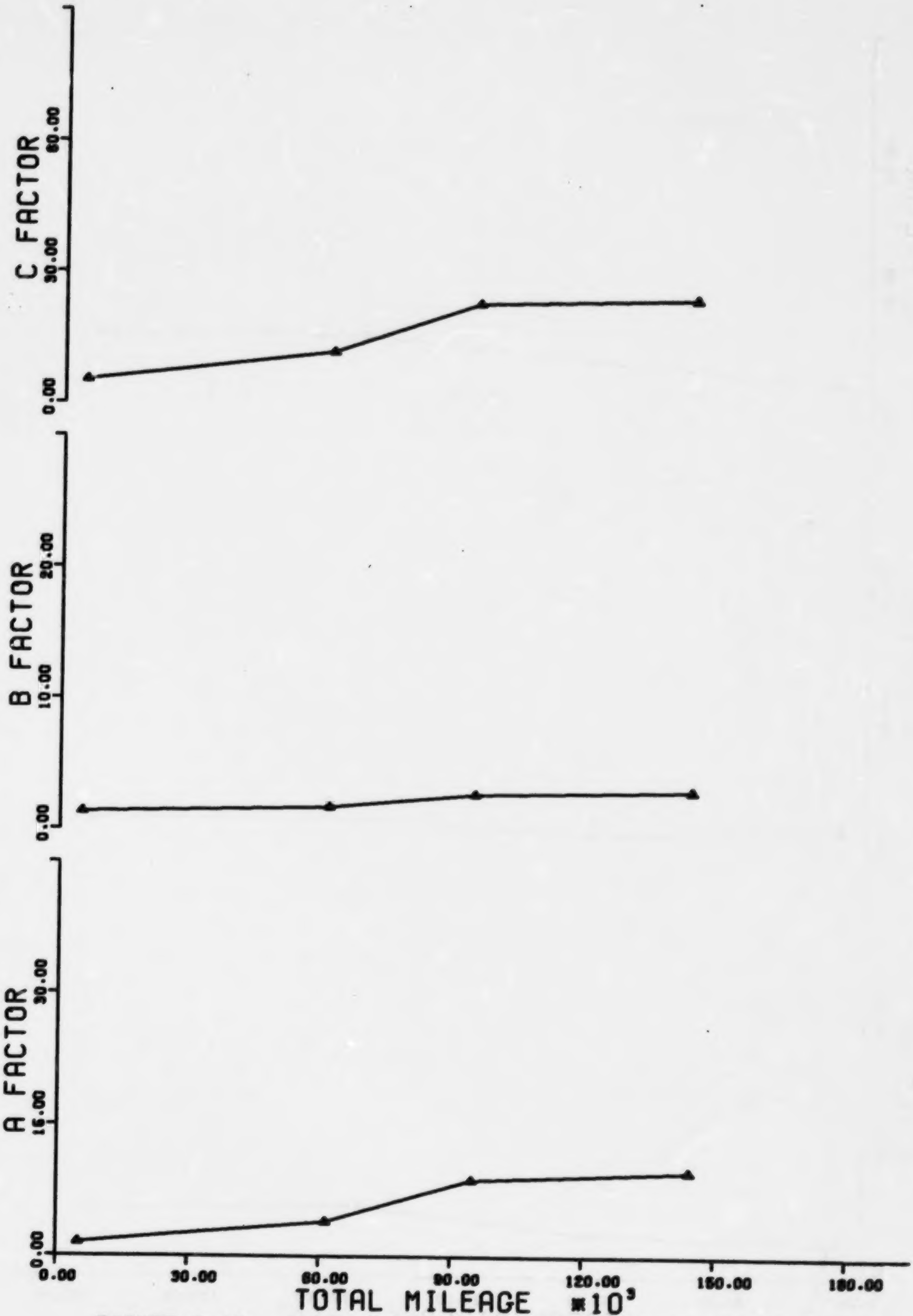

FIGURE D-13. UNIT 105 LEFT BANK DETROIT DIESEL 8V-71N

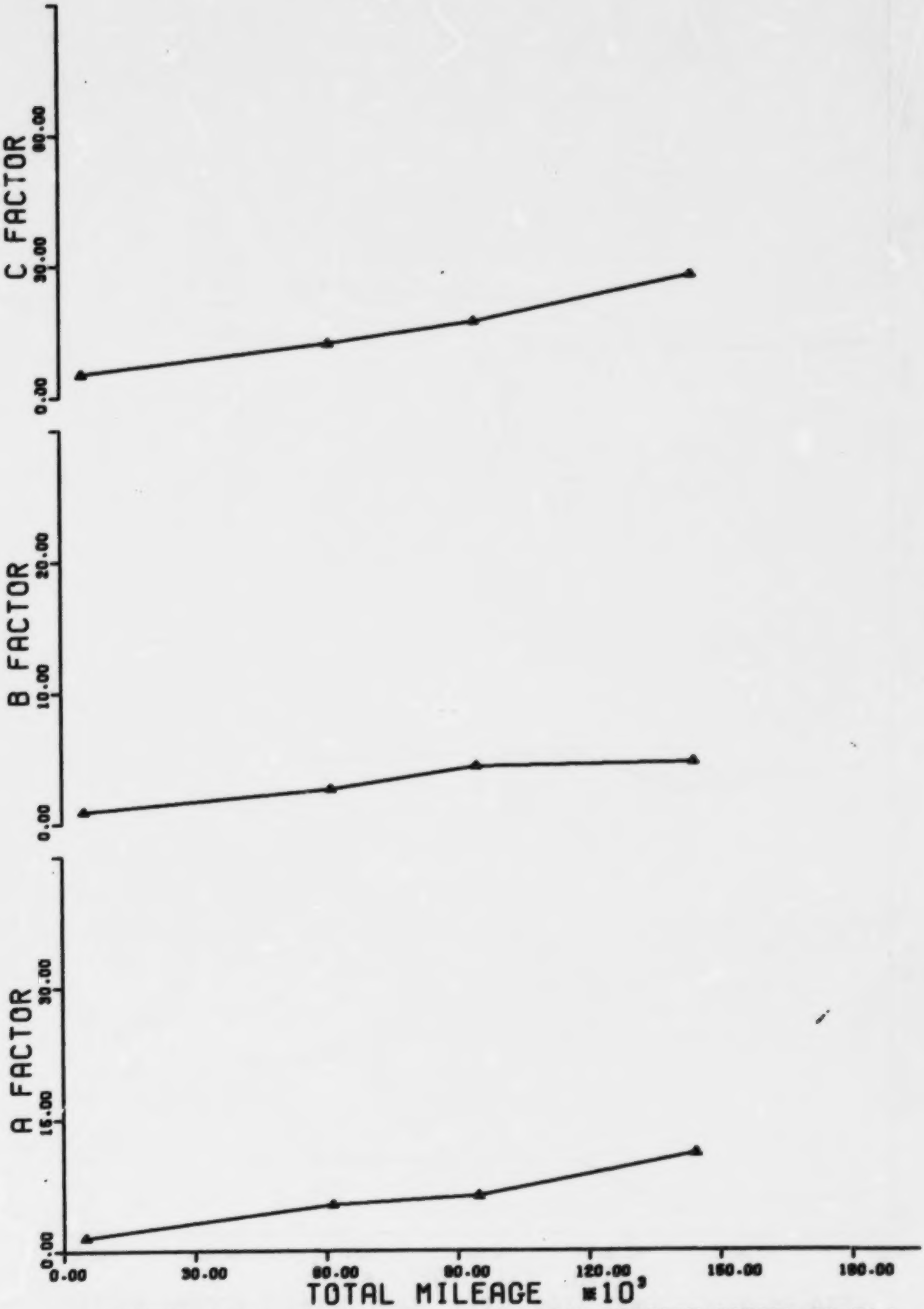

FIGURE D-14. UNIT 105 RIGHT BANK DETROIT DIESEL 8V-71N

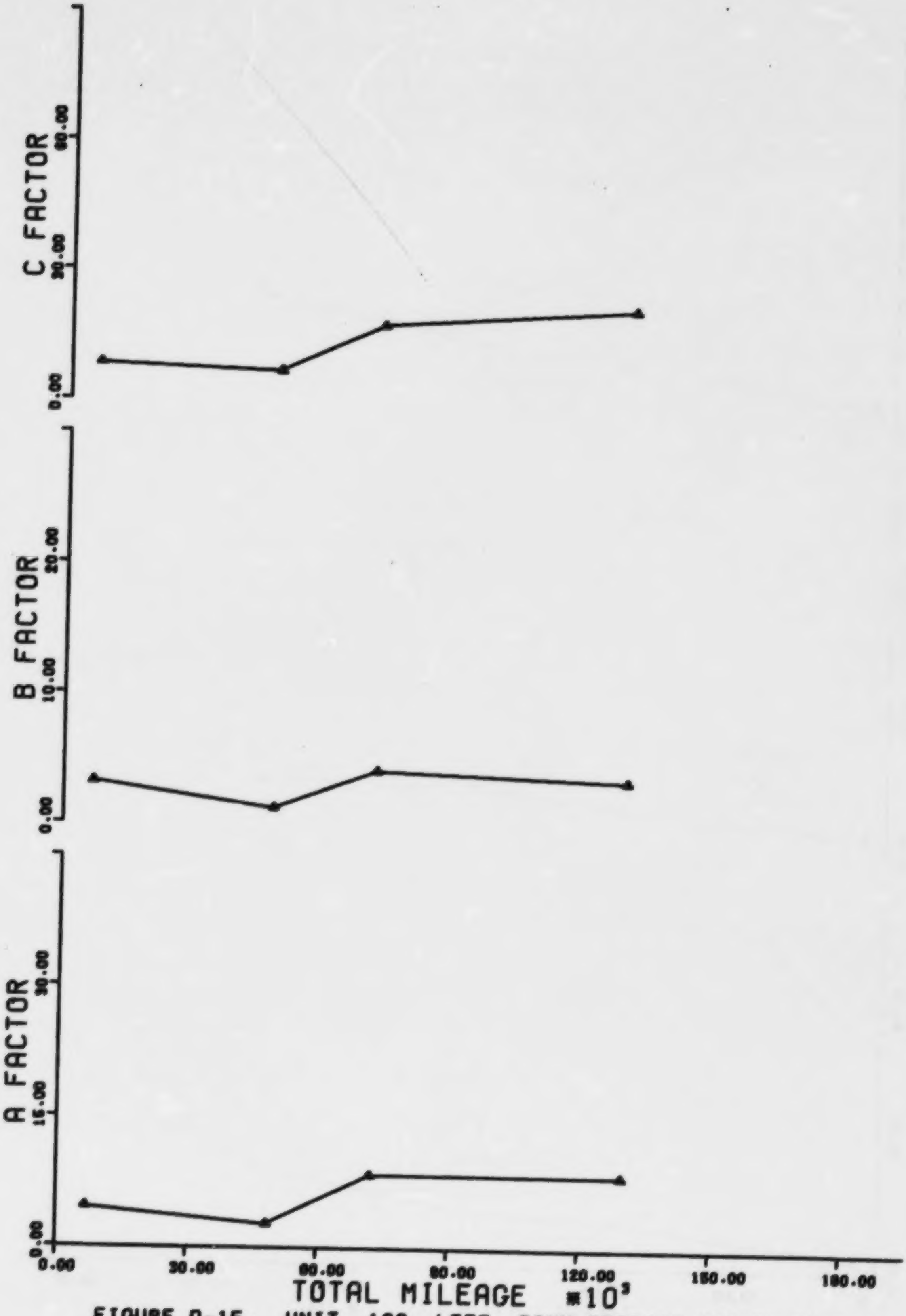

FIGURE D-15. UNIT 106 LEFT BANK DETROIT DIESEL 8V-71N

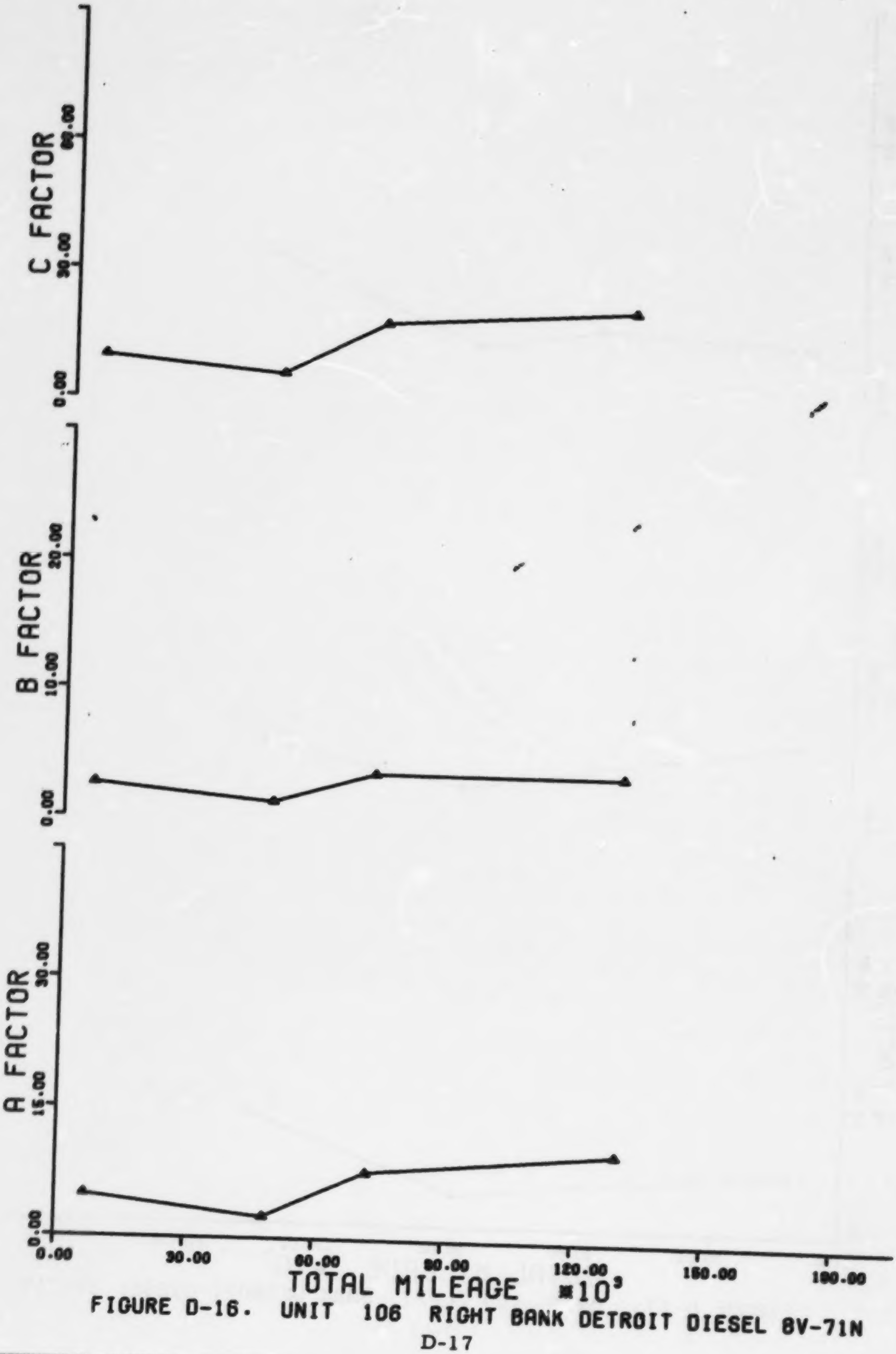

FIGURE D-16. UNIT 106 RIGHT BANK DETROIT DIESEL 8V-71N

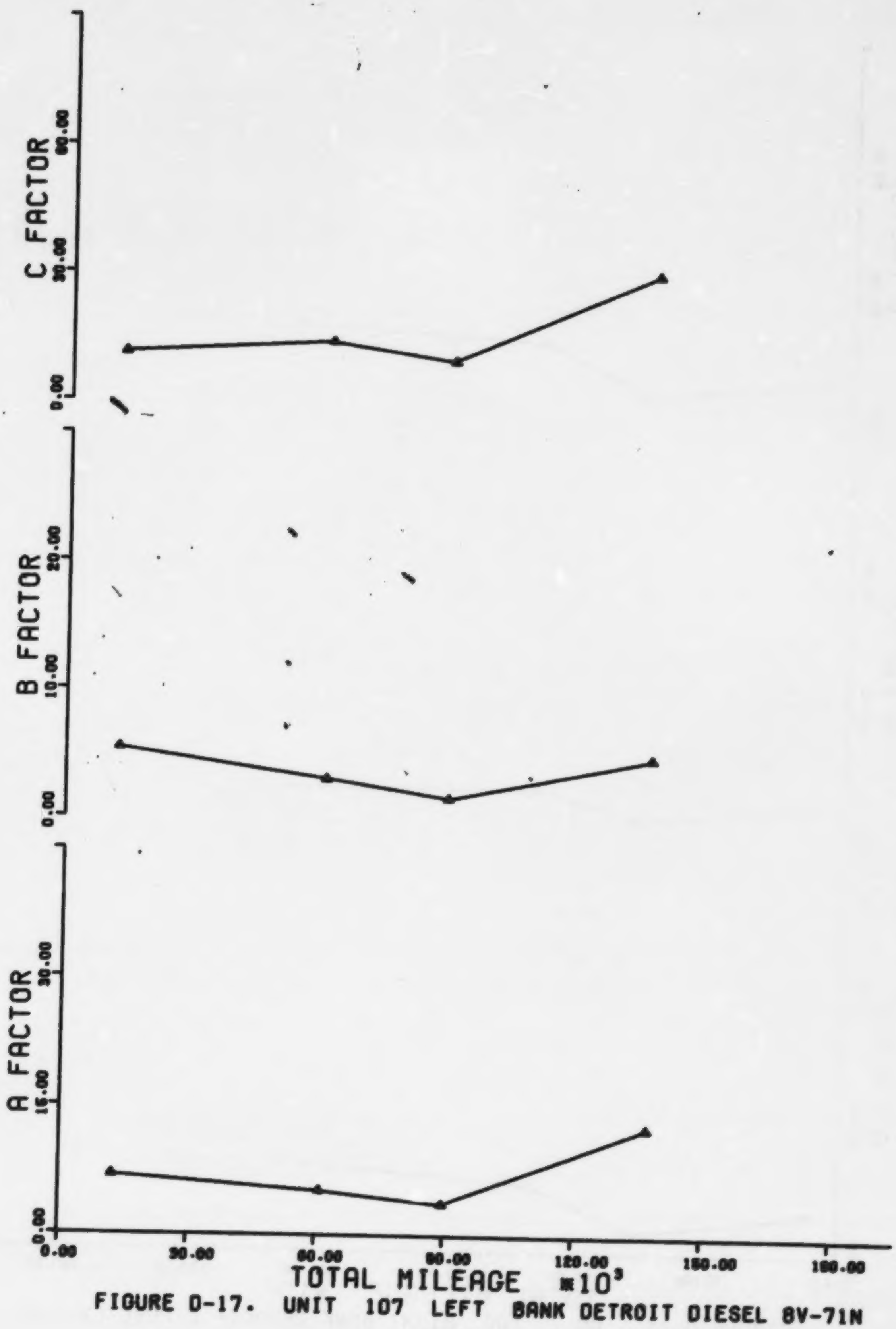

FIGURE D-17. UNIT 107 LEFT BANK DETROIT DIESEL 8V-71N

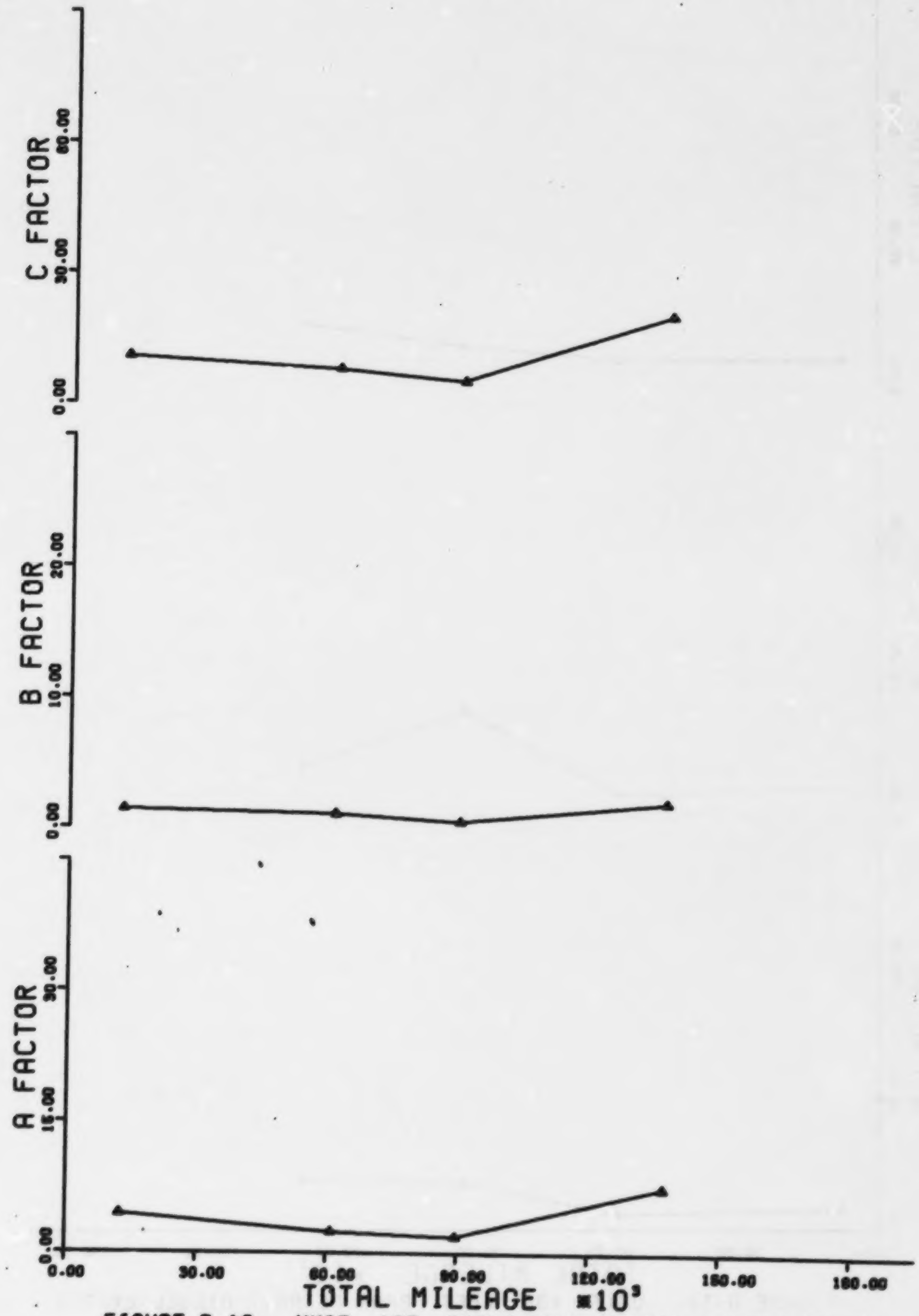

FIGURE D-18. UNIT 107 RIGHT BANK DETROIT DIESEL 8V-71N

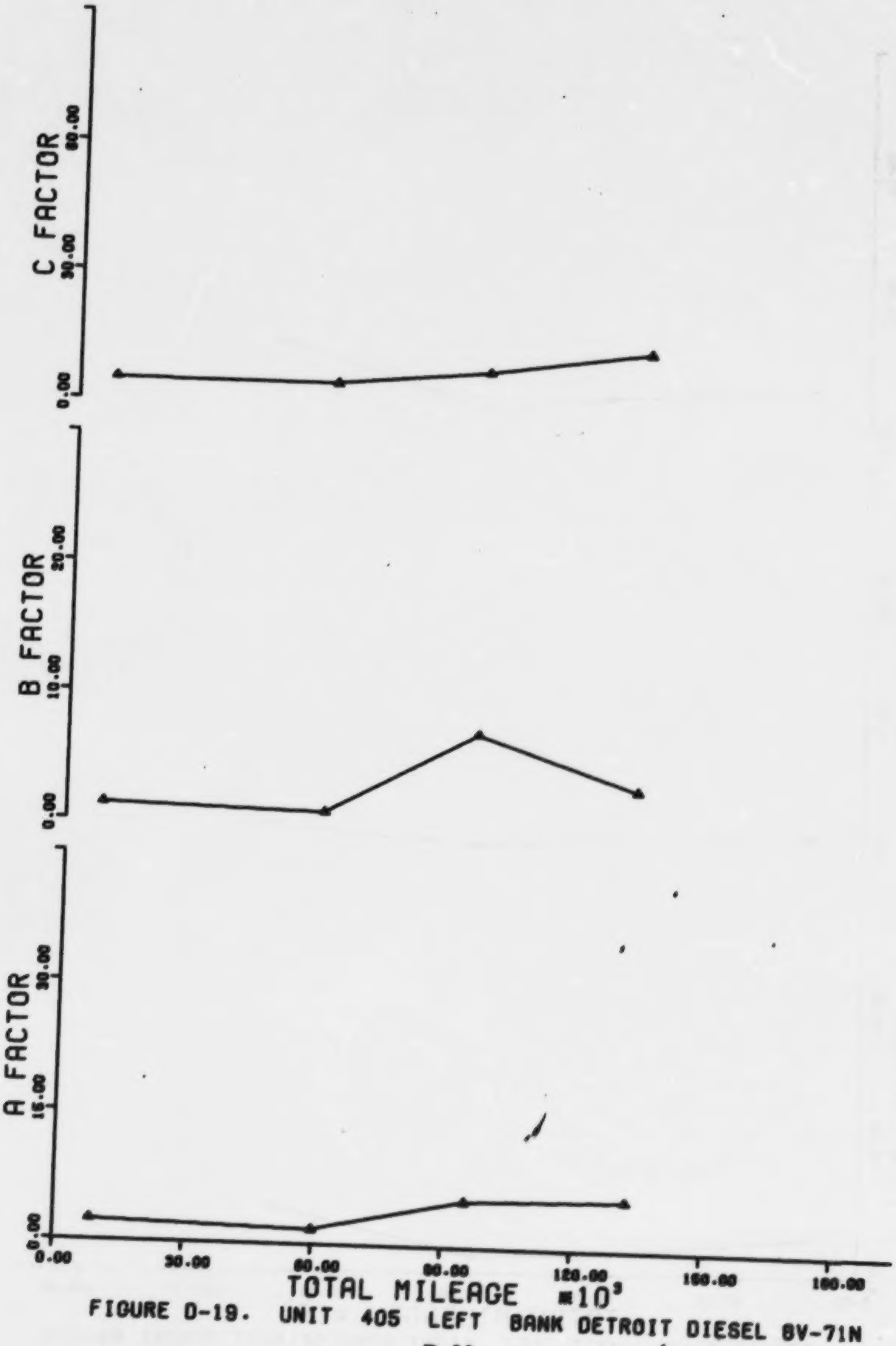

FIGURE D-19. UNIT 405 LEFT BANK DETROIT DIESEL 8V-71N

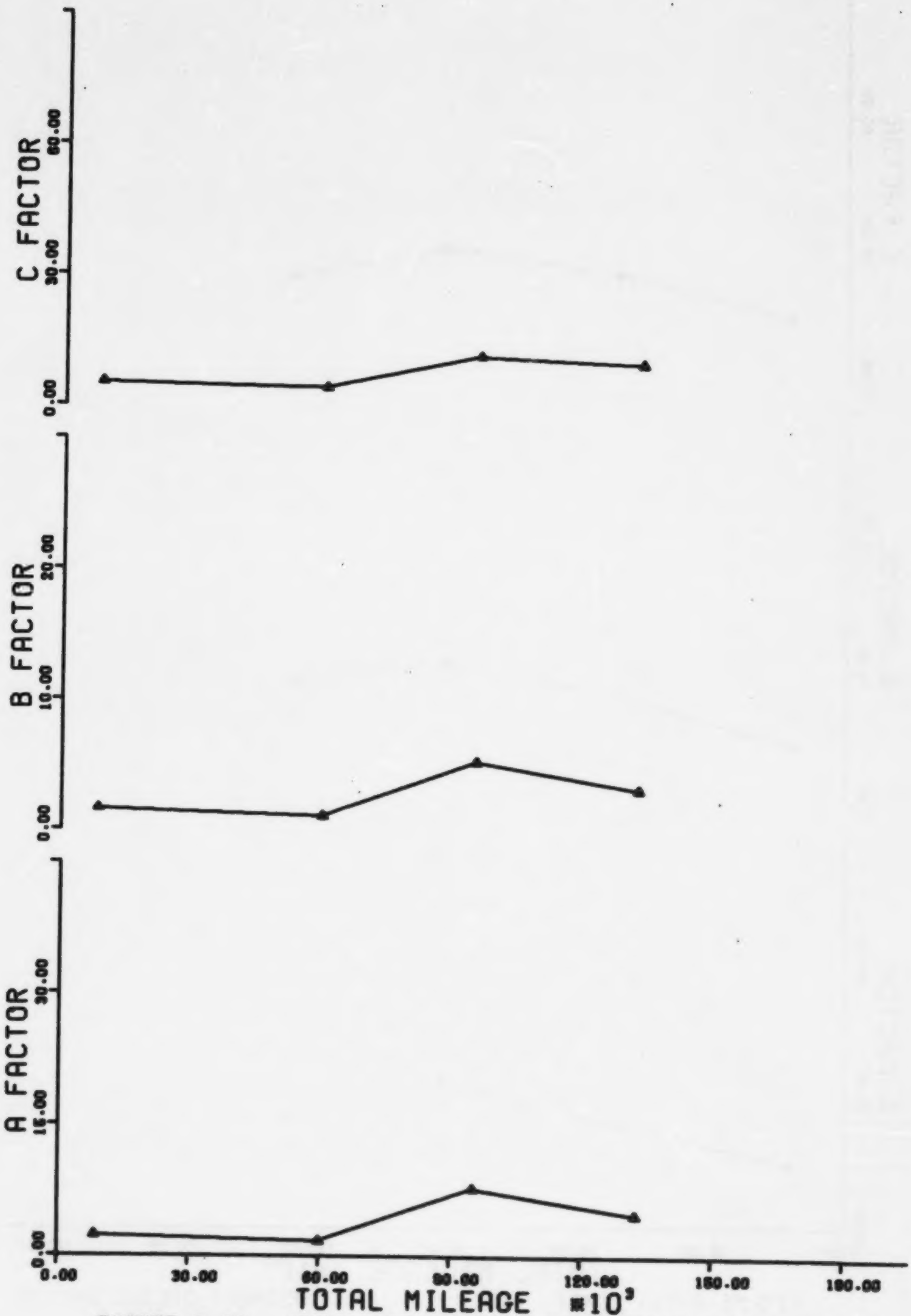

FIGURE D-20. UNIT 405 RIGHT BANK DETROIT DIESEL 8V-71N

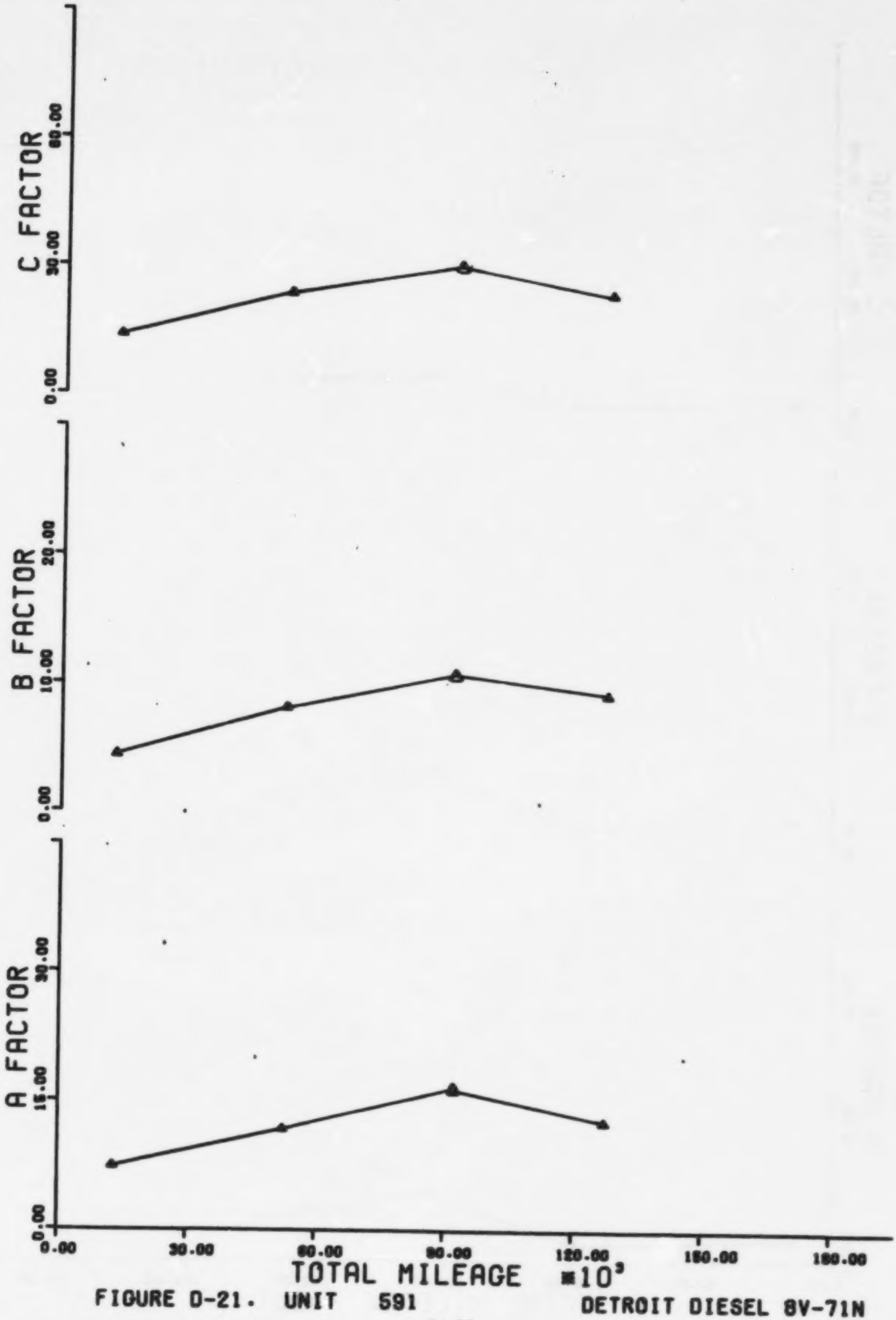

FIGURE D-21. UNIT 591 DETROIT DIESEL 8V-71N

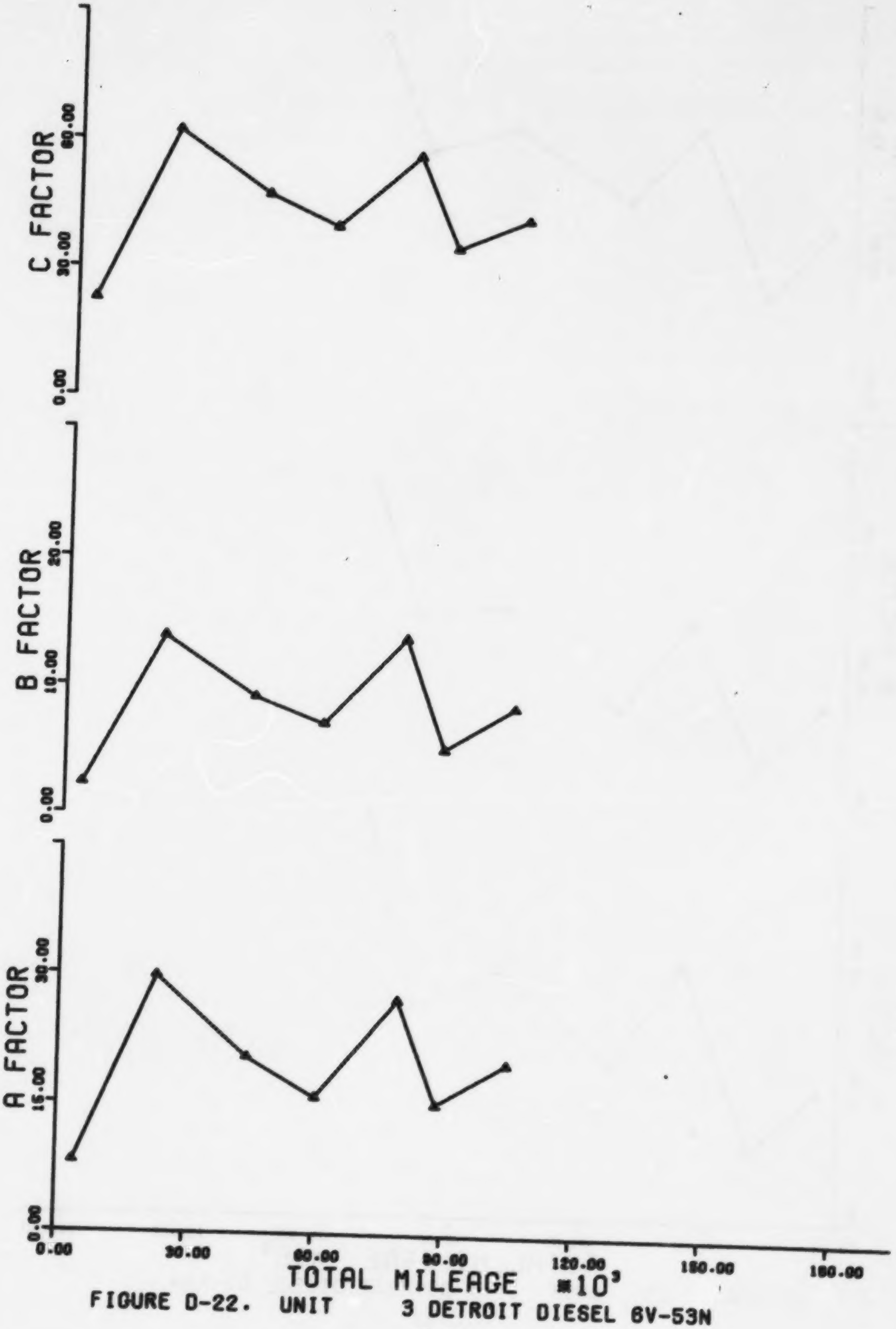

FIGURE D-22. UNIT 3 DETROIT DIESEL 6V-53N

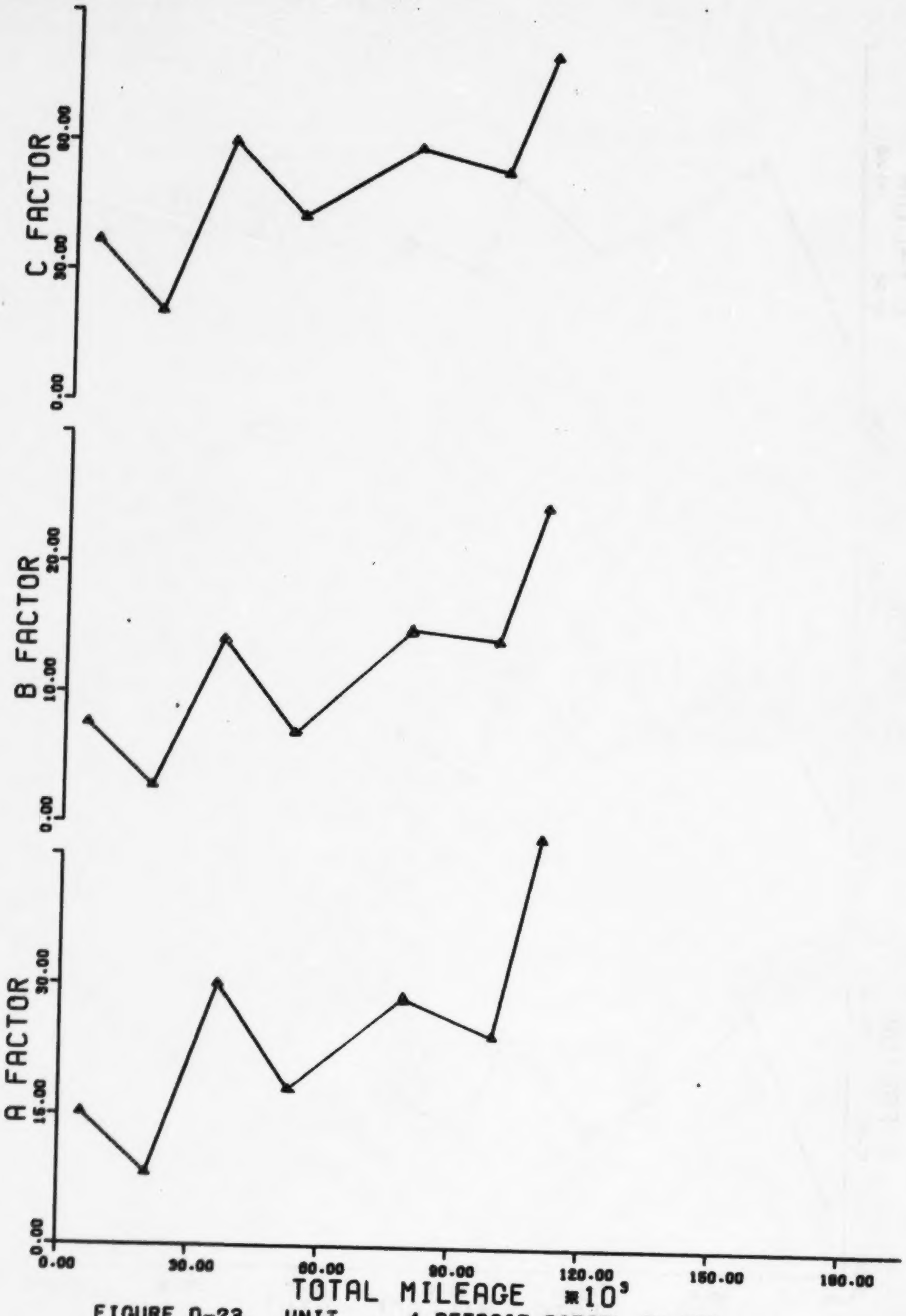

FIGURE D-23. UNIT 4 DETROIT DIESEL 6V-53N

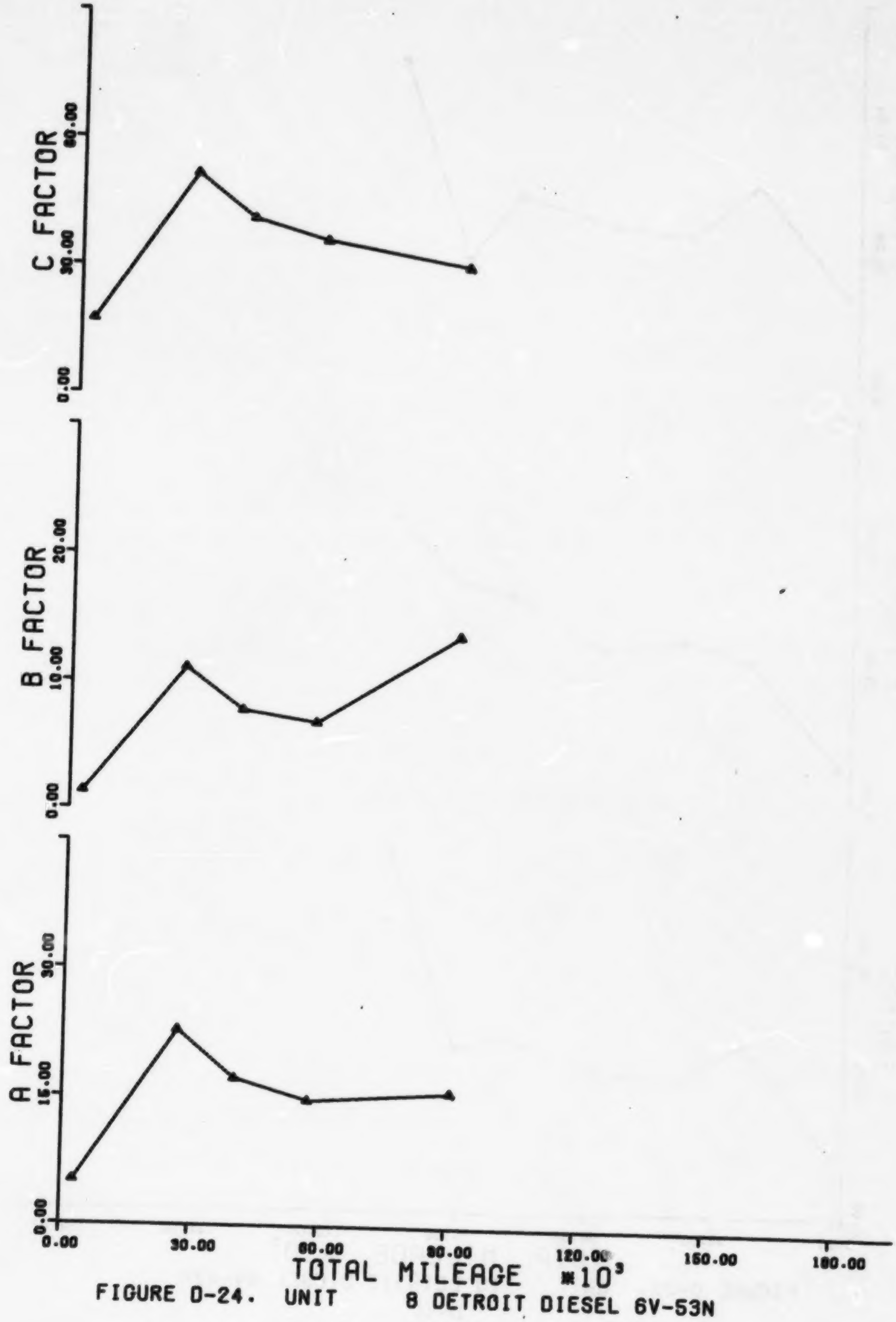

FIGURE D-24. UNIT 8 DETROIT DIESEL 6V-53N

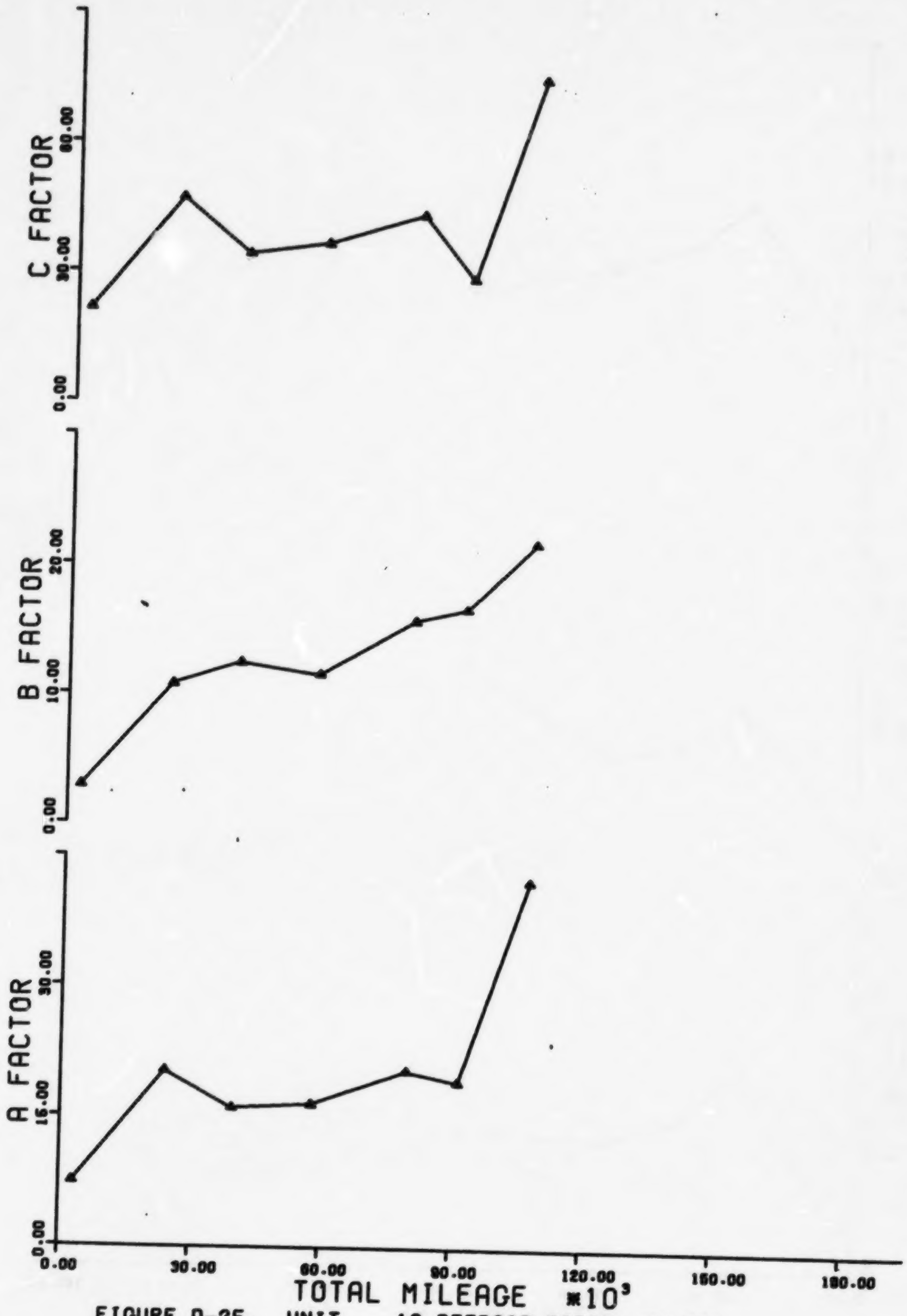

FIGURE D-25. UNIT 10 DETROIT DIESEL 6V-53N

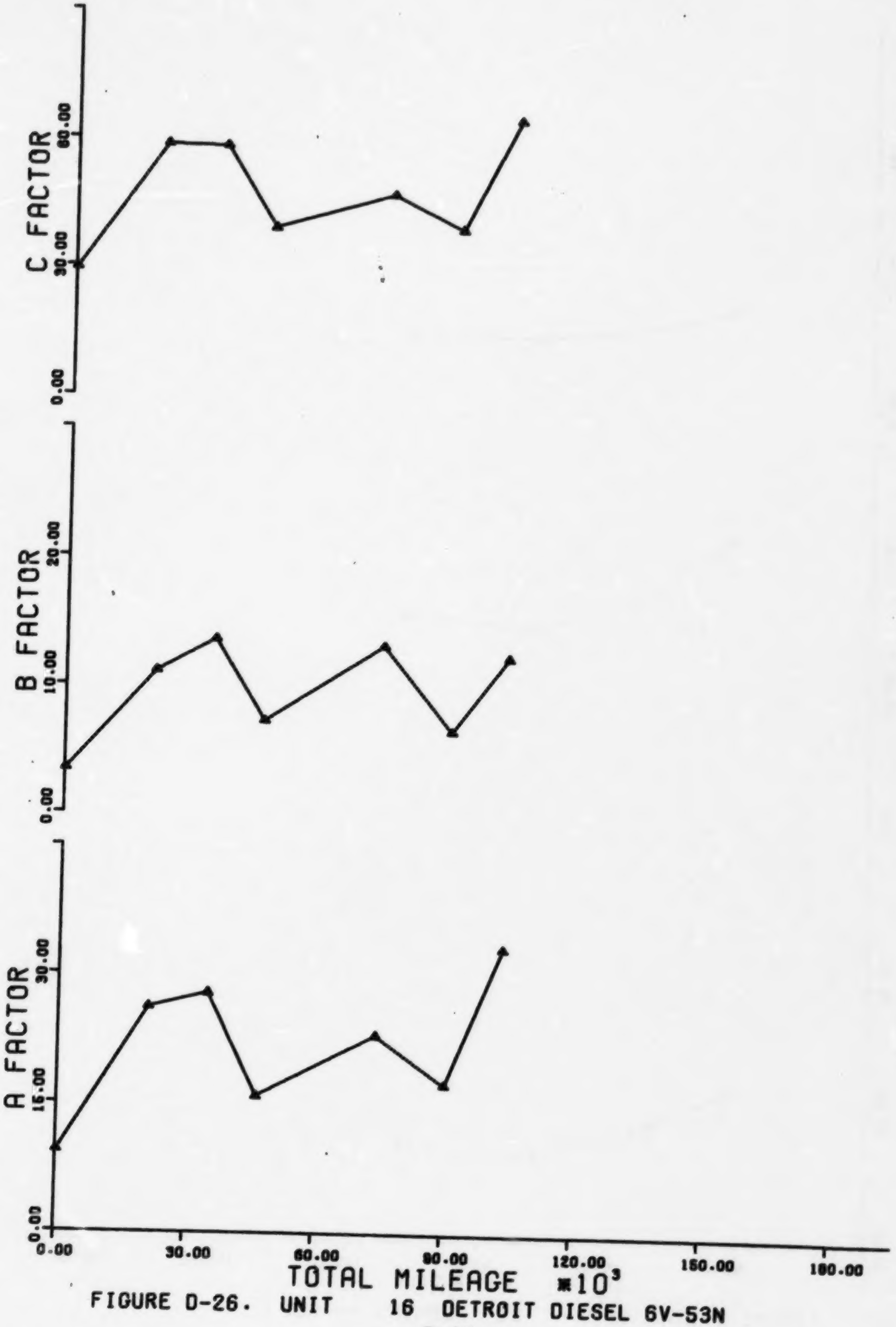

FIGURE D-26. UNIT 16 DETROIT DIESEL 6V-53N

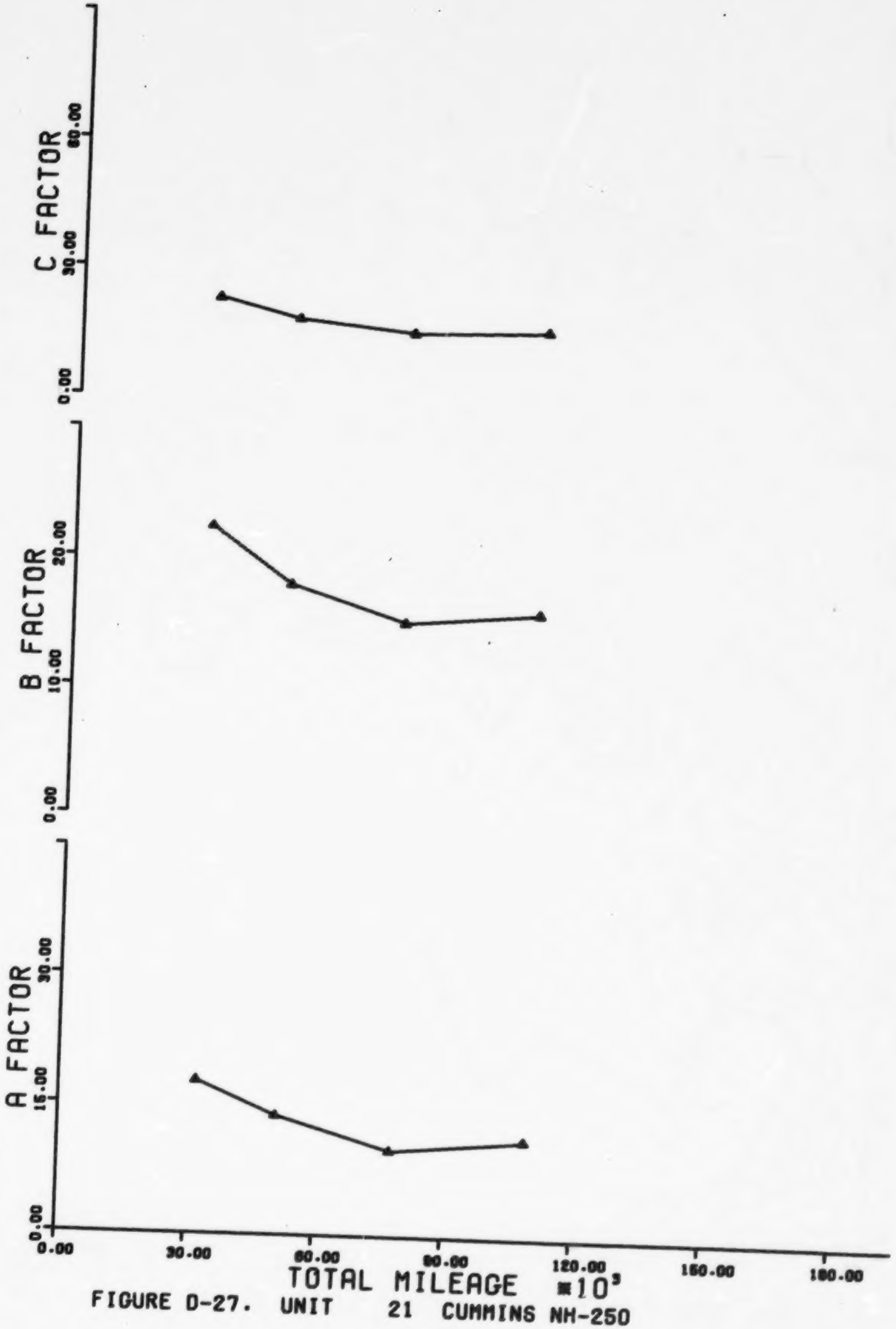

FIGURE D-27. UNIT 21 CUMMINS NH-250

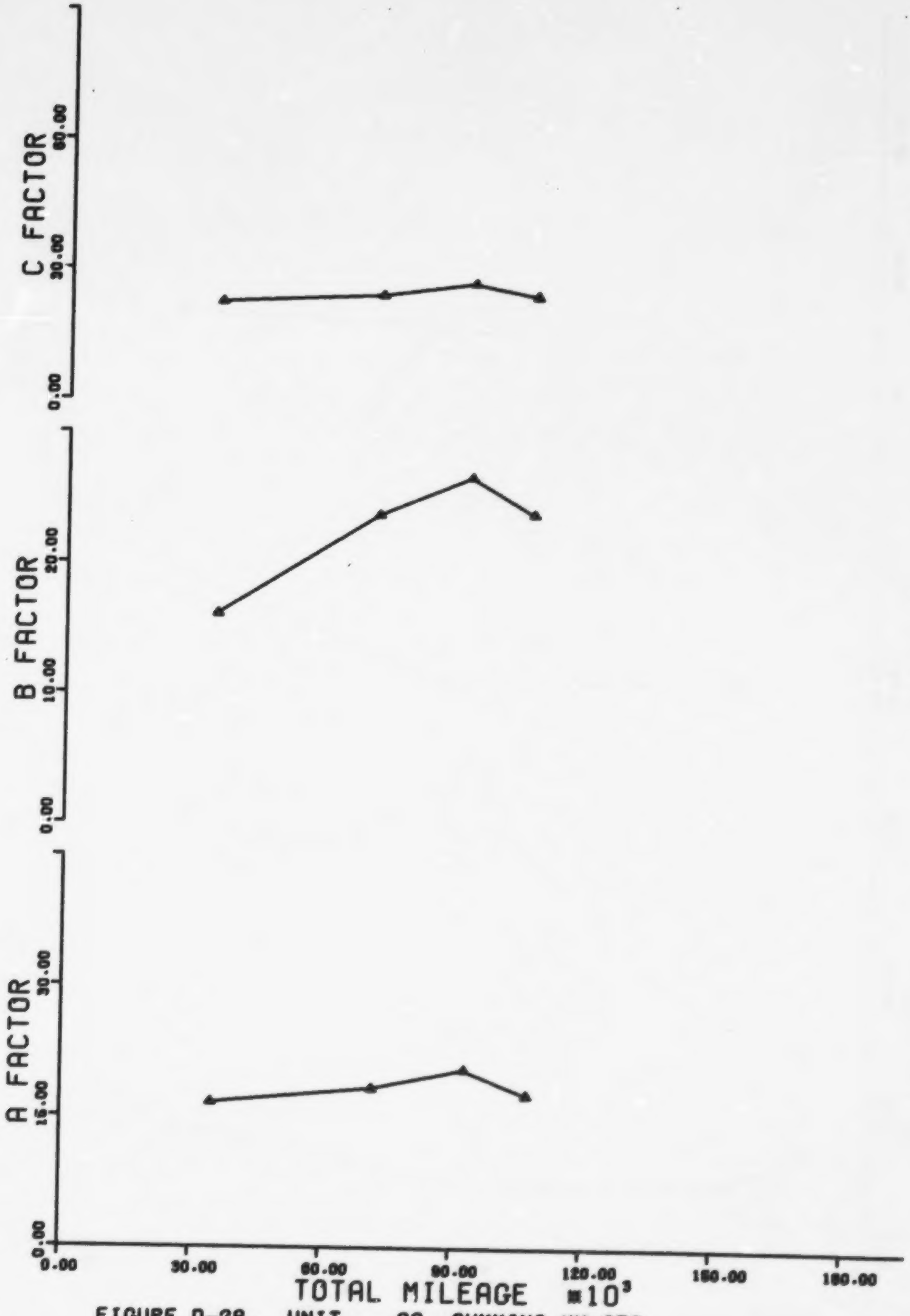

FIGURE D-28. UNIT 22 CUMMINS NH-250

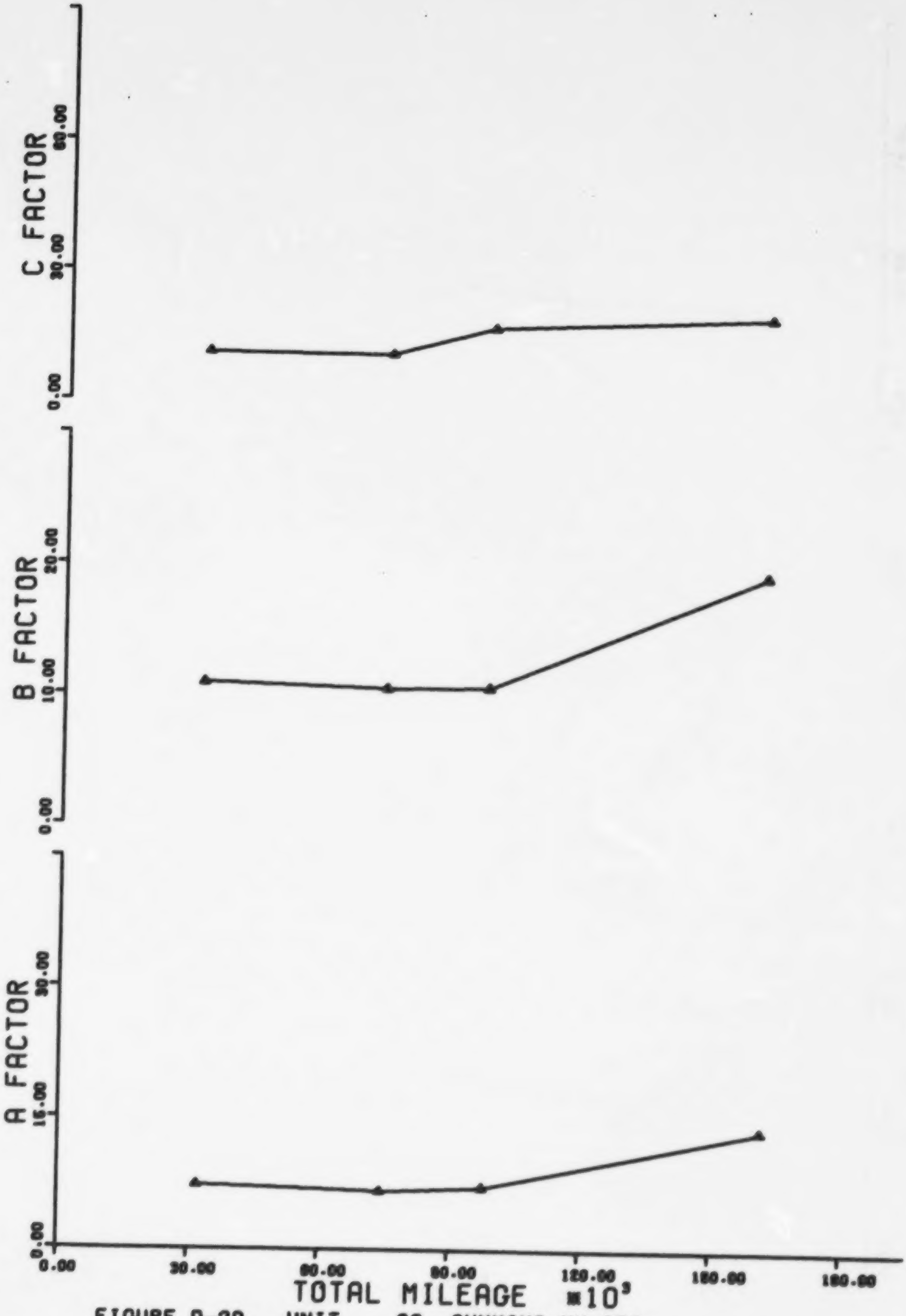

FIGURE D-29. UNIT 62 CUMMINS NH-250

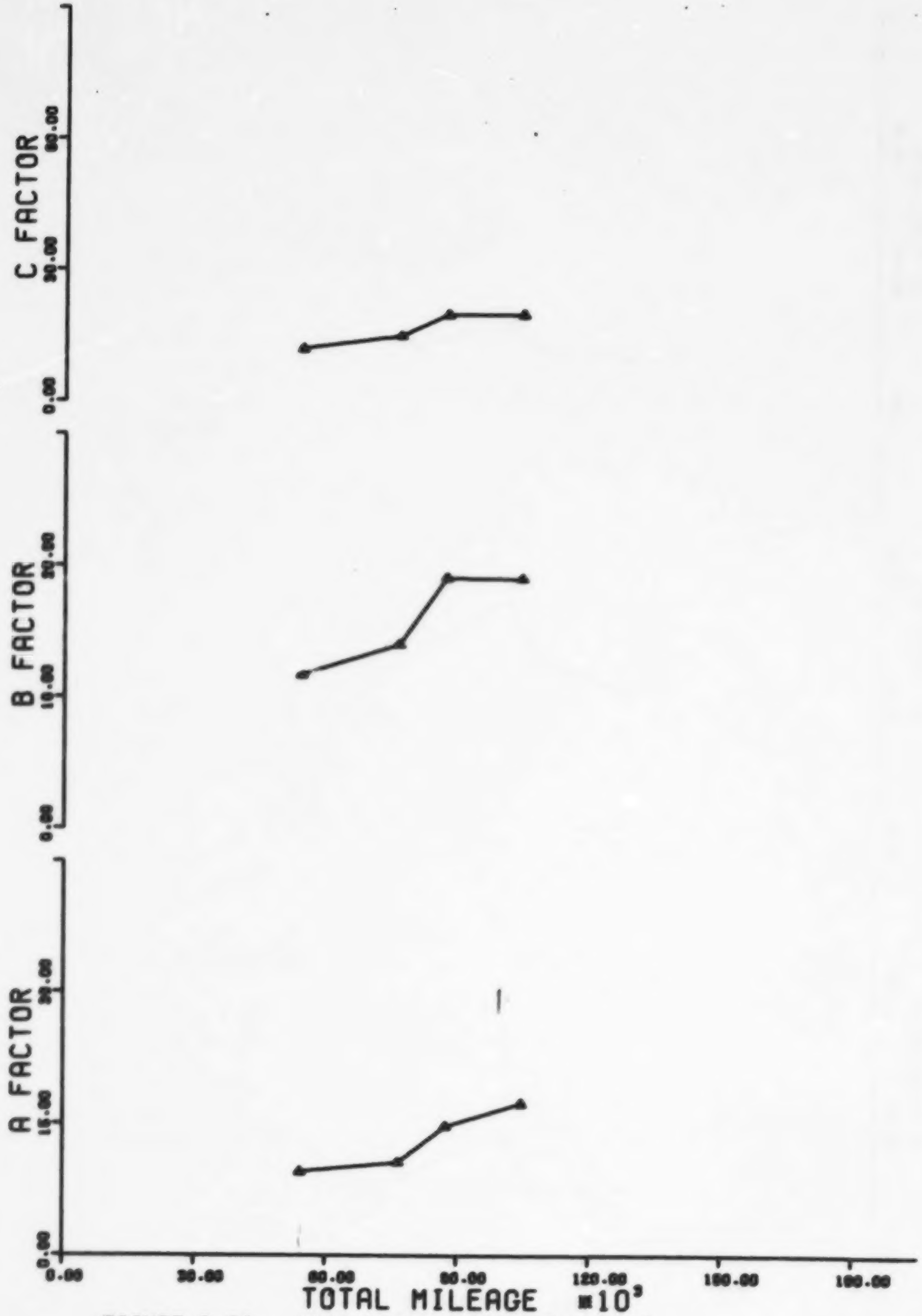

FIGURE D-30. UNIT 15743 CUMMINS NH-250

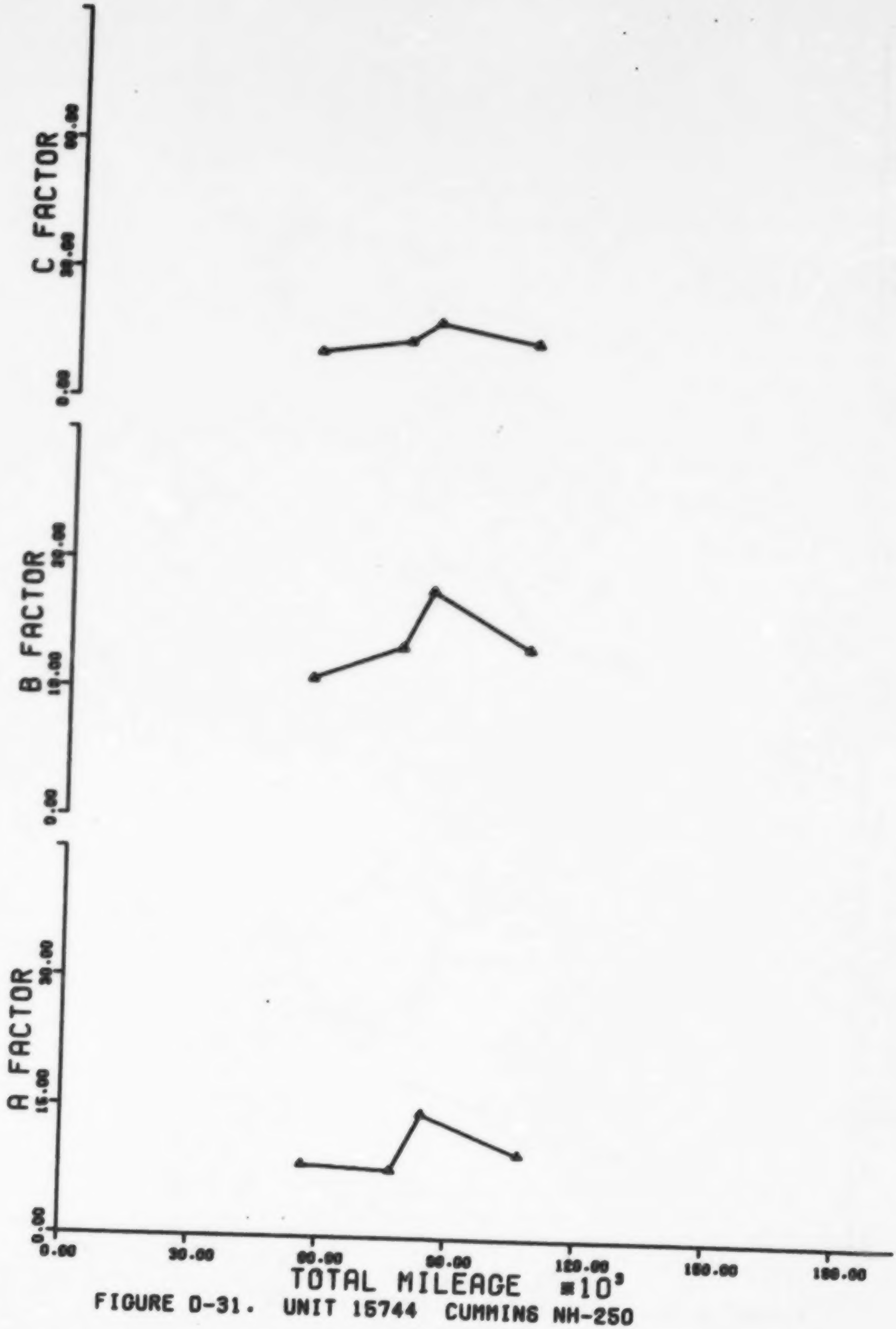

FIGURE D-31. UNIT 15744 CUMMINS NH-250

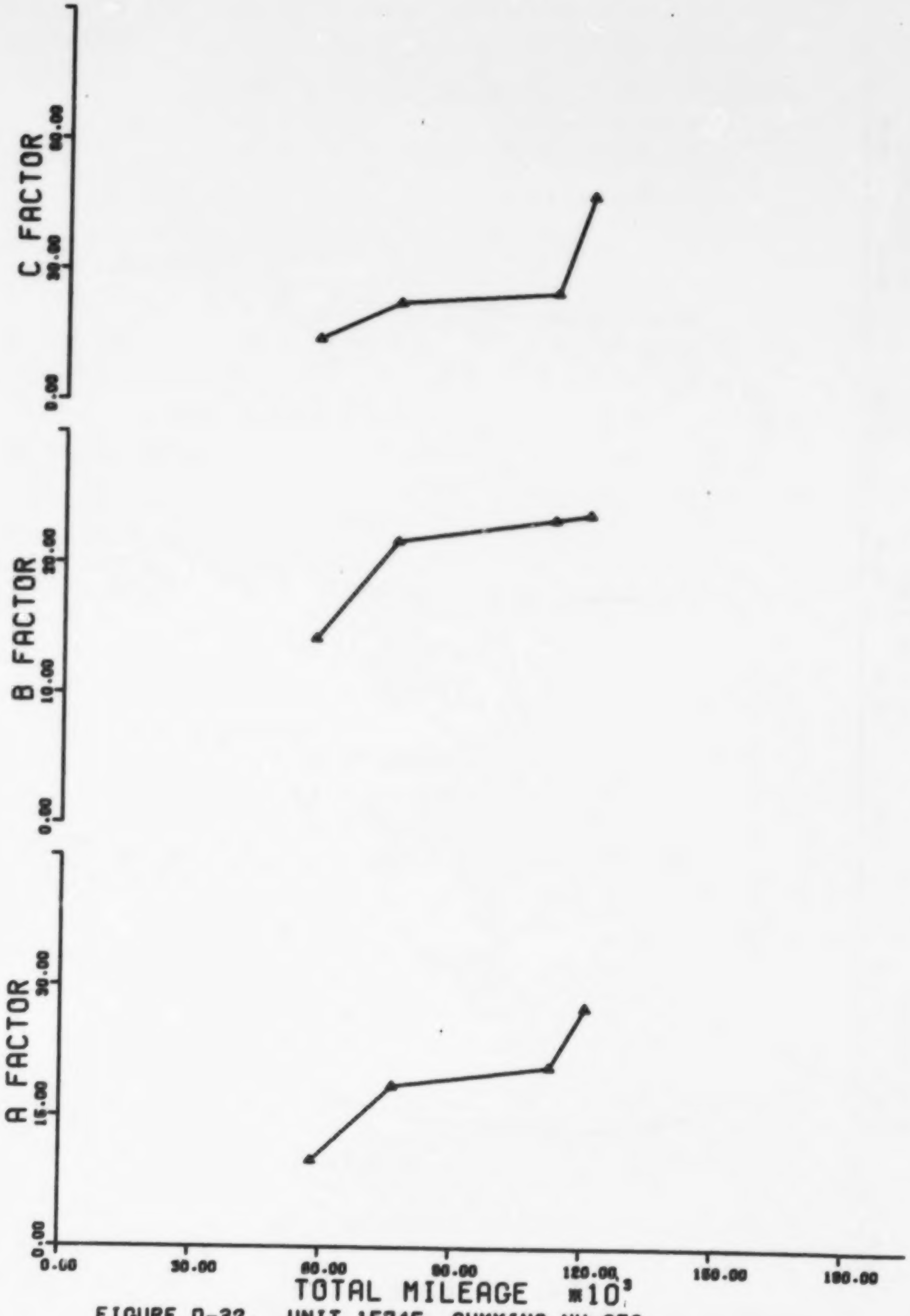

FIGURE D-32. UNIT 15745 CUMMINS NH-250

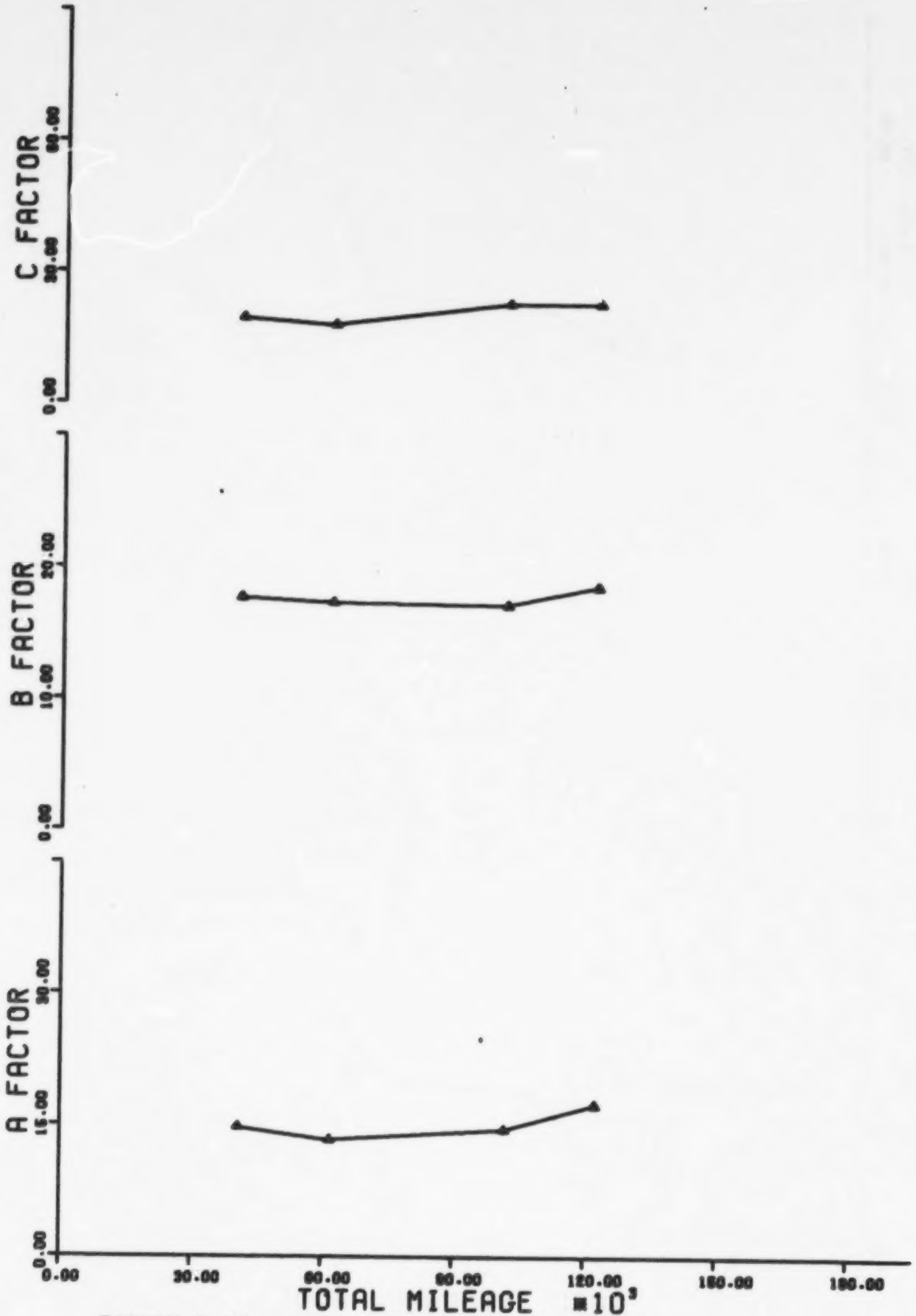

FIGURE D-33. UNIT 15746 CUMMINS NH-250

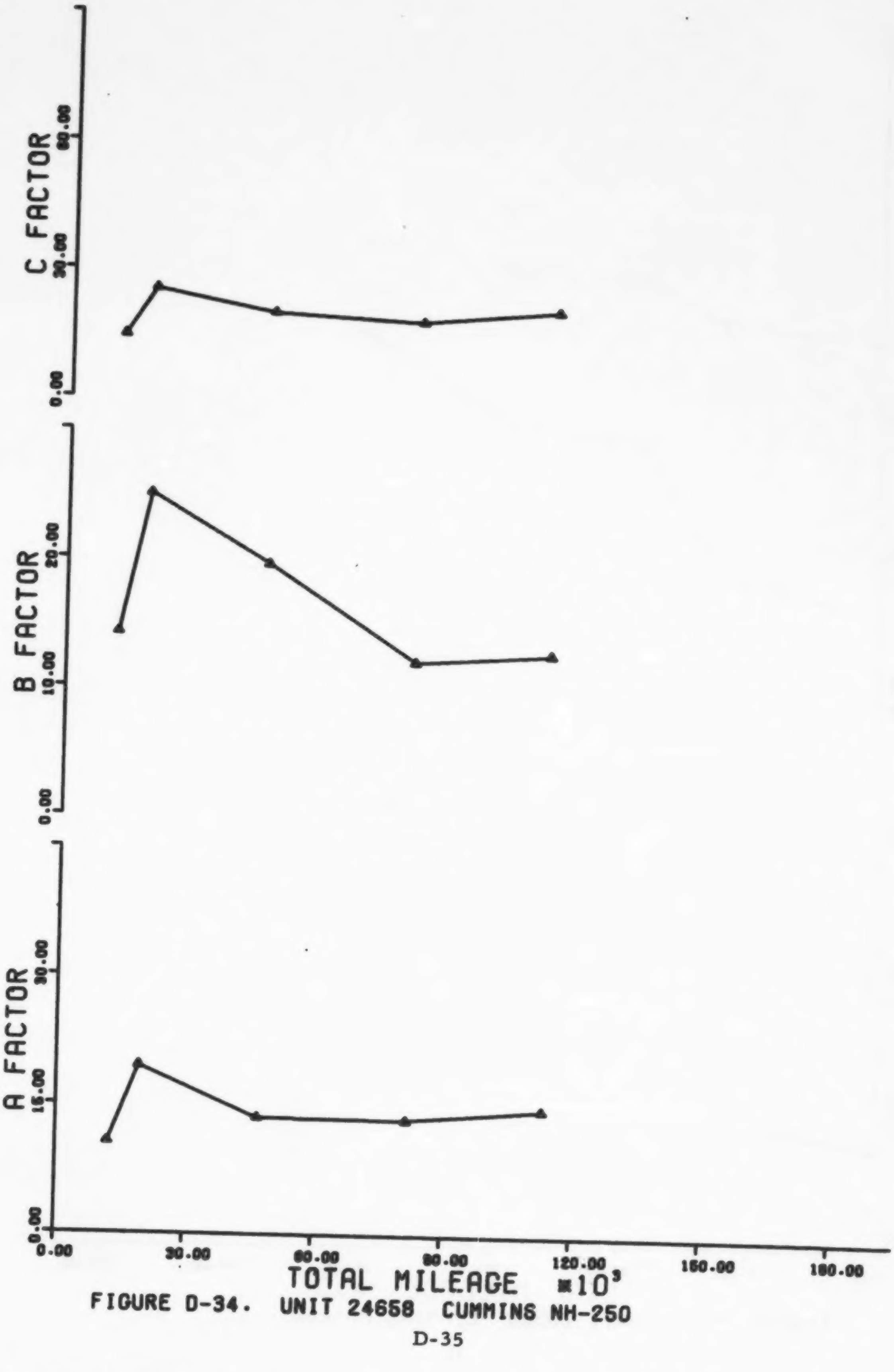

FIGURE D-34. UNIT 24658 CUMMINS NH-250

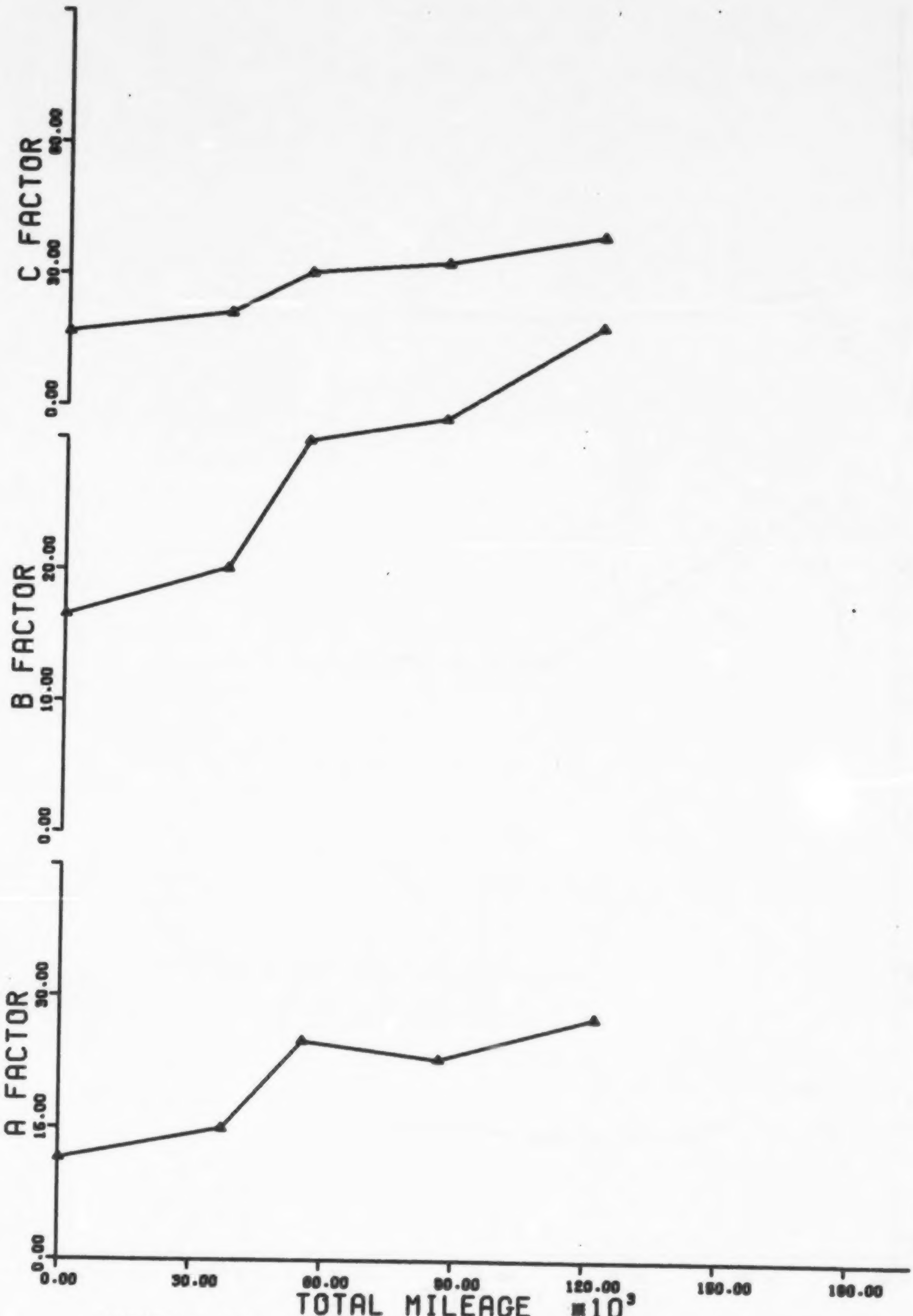

FIGURE D-35. UNIT 26353 CUMMINS NH-250

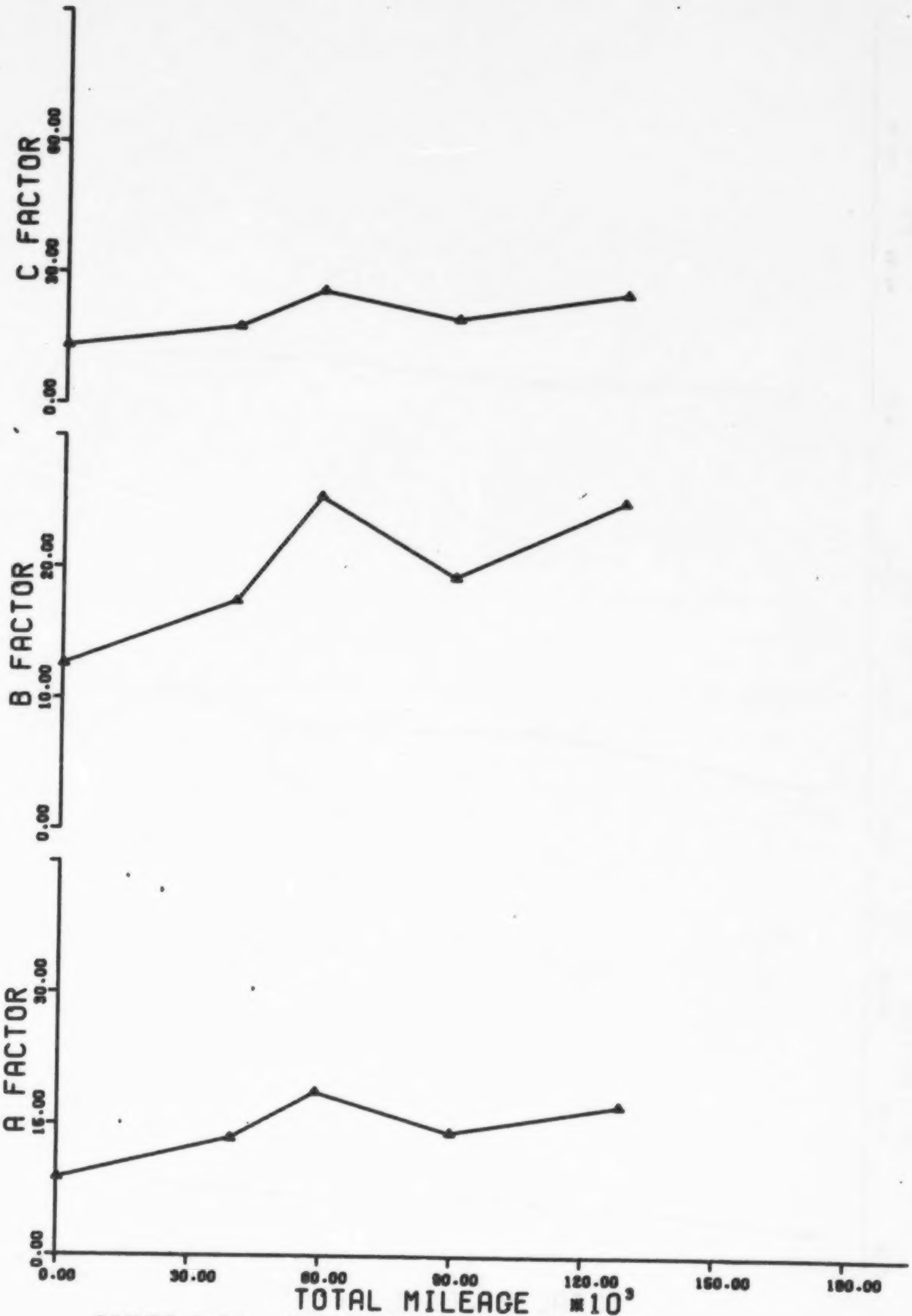

FIGURE D-36. UNIT 26354 CUMMINS NH-250

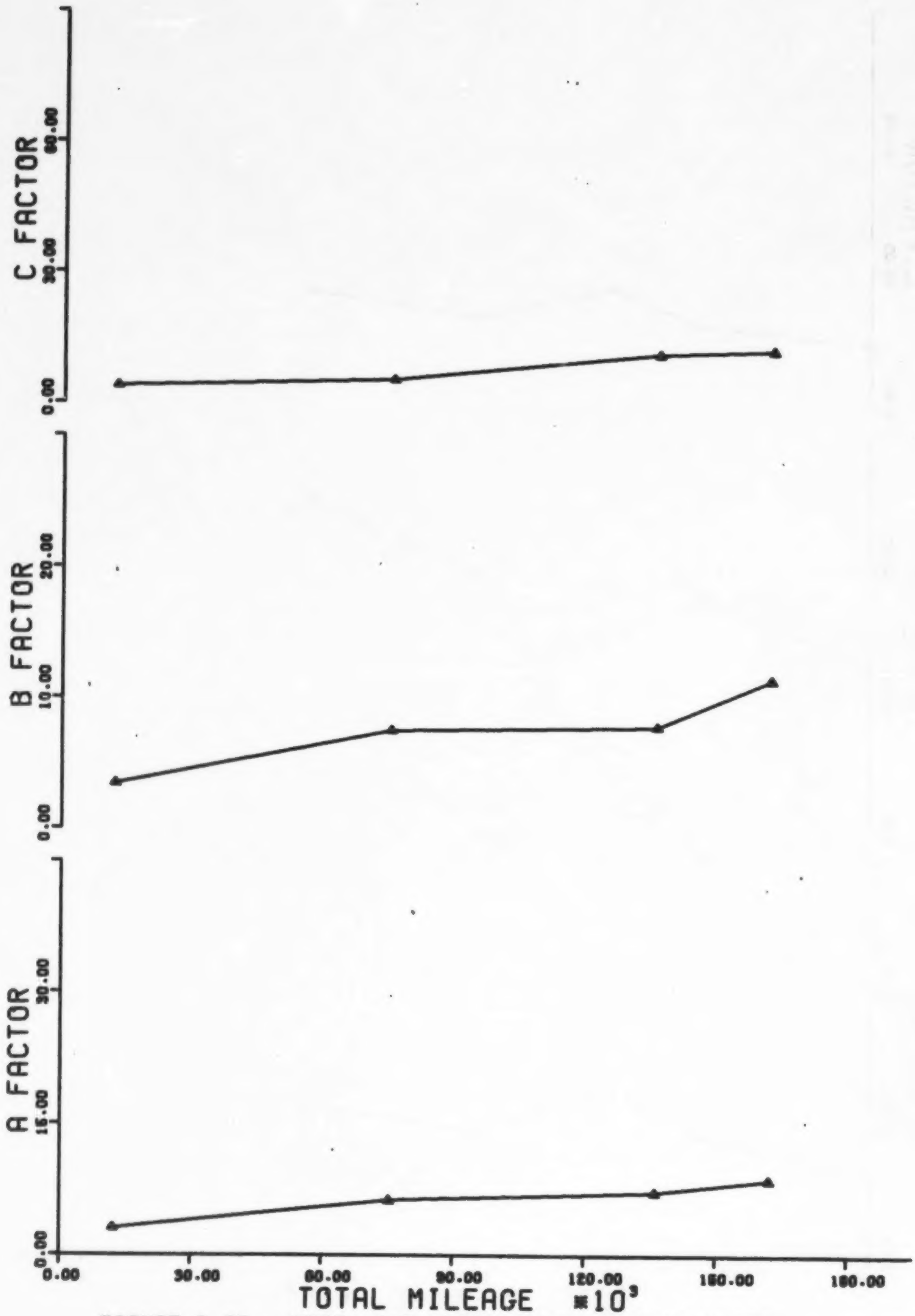

FIGURE D-37. UNIT 415 LEFT BANK CUMMINS V-903

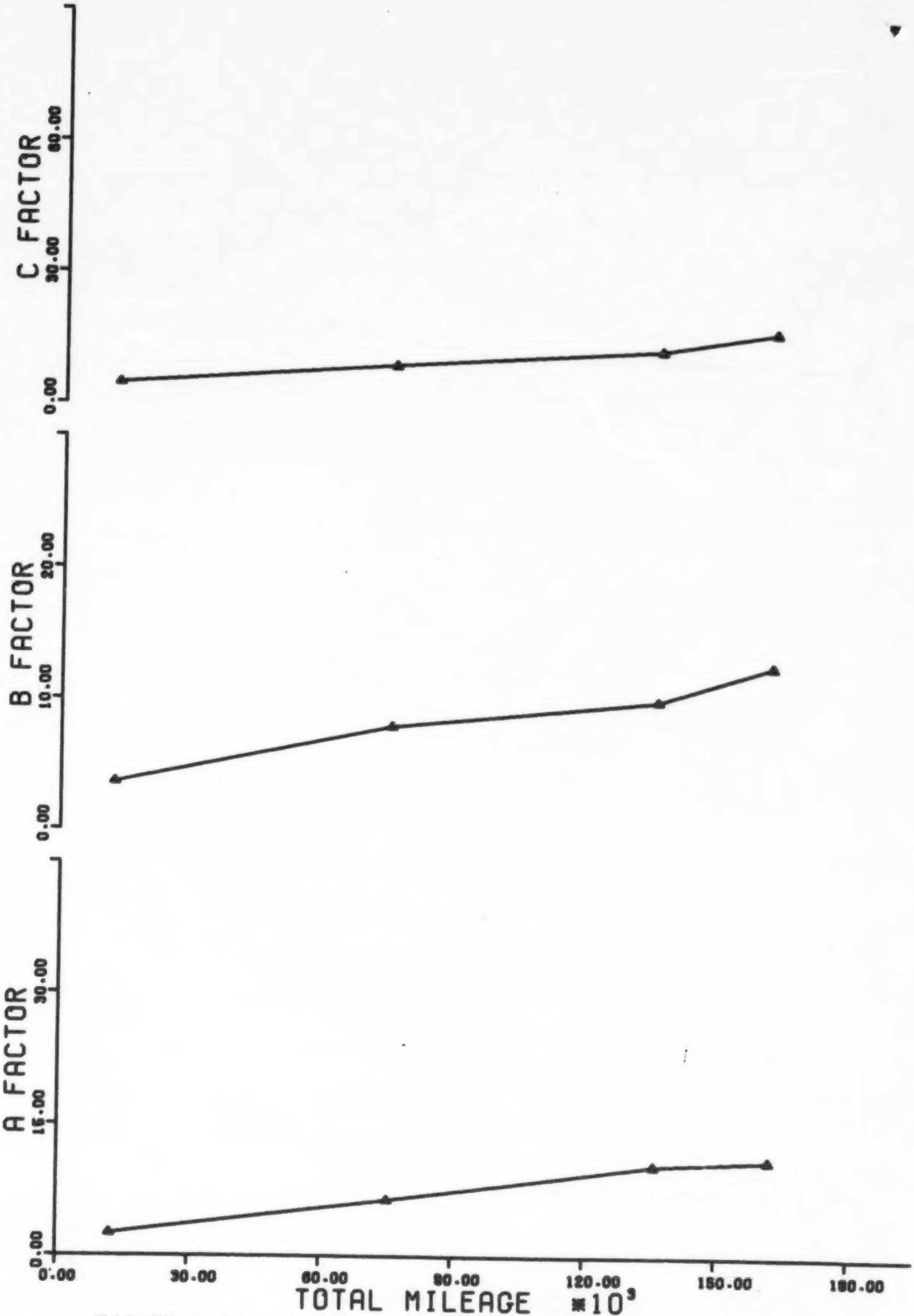

FIGURE D-38. UNIT 415 RIGHT BANK CUMMINS V-903

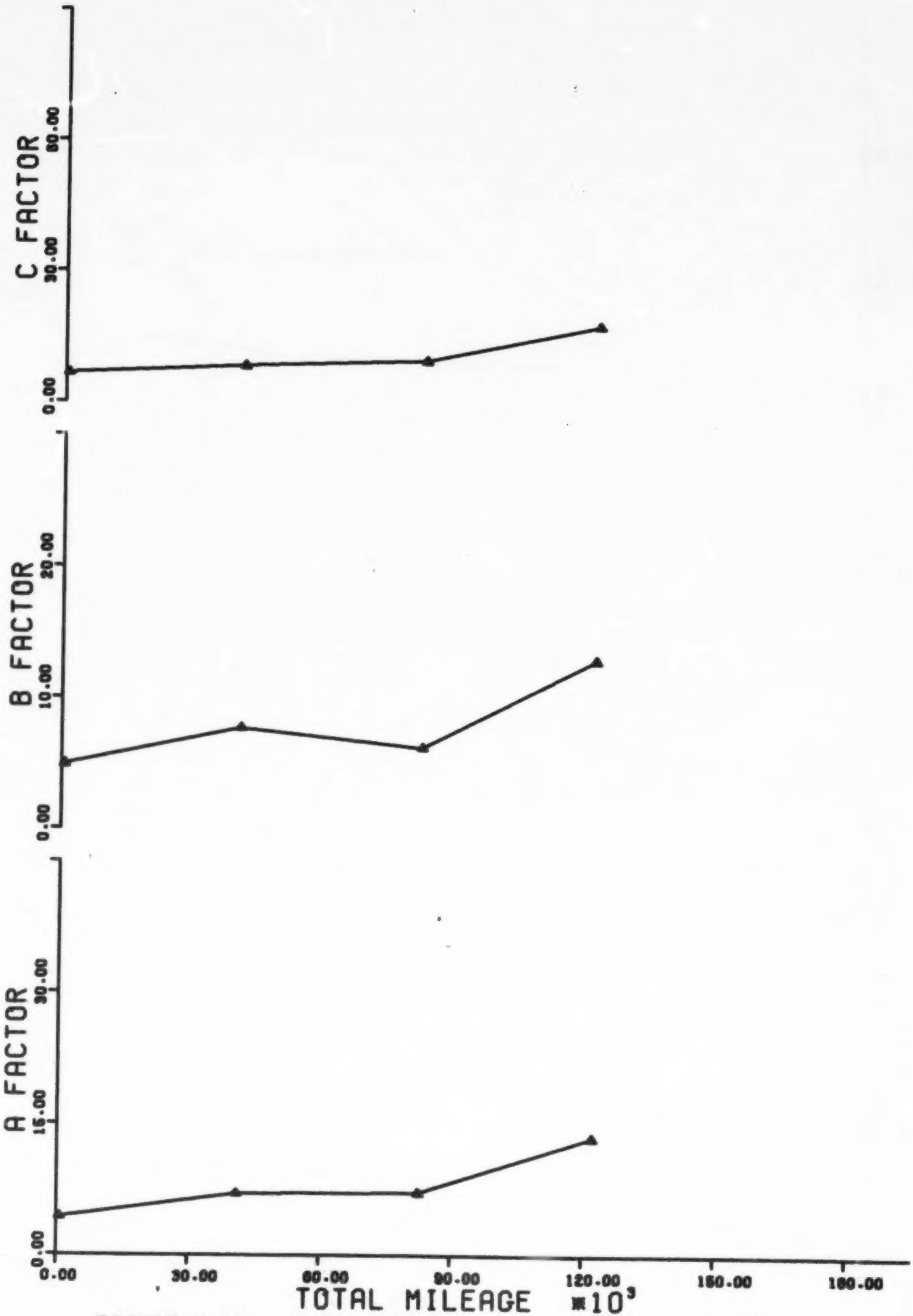

FIGURE D-39. UNIT 966 CUMMINS V-903

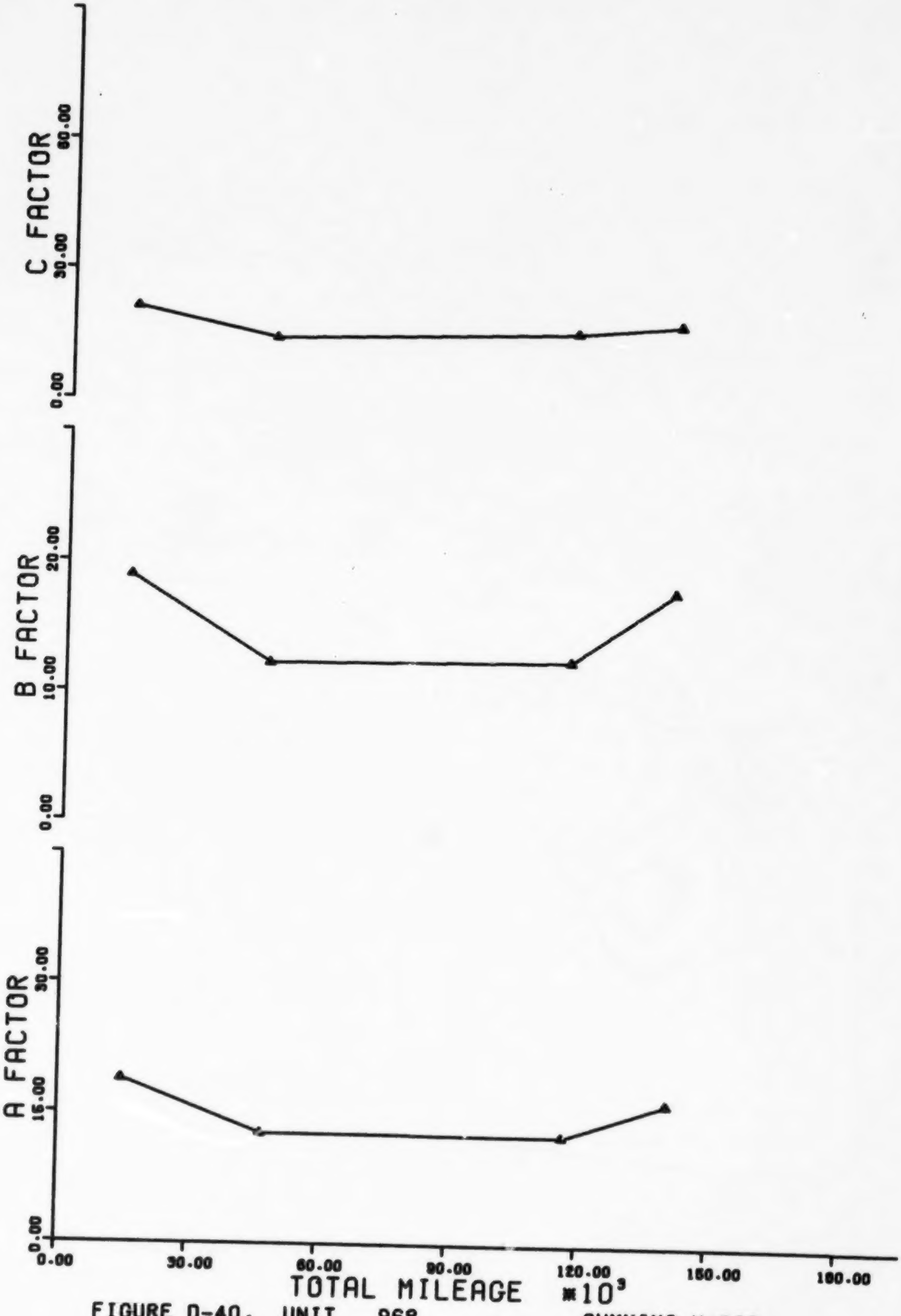

FIGURE D-40. UNIT 968 CUMMINS V-903

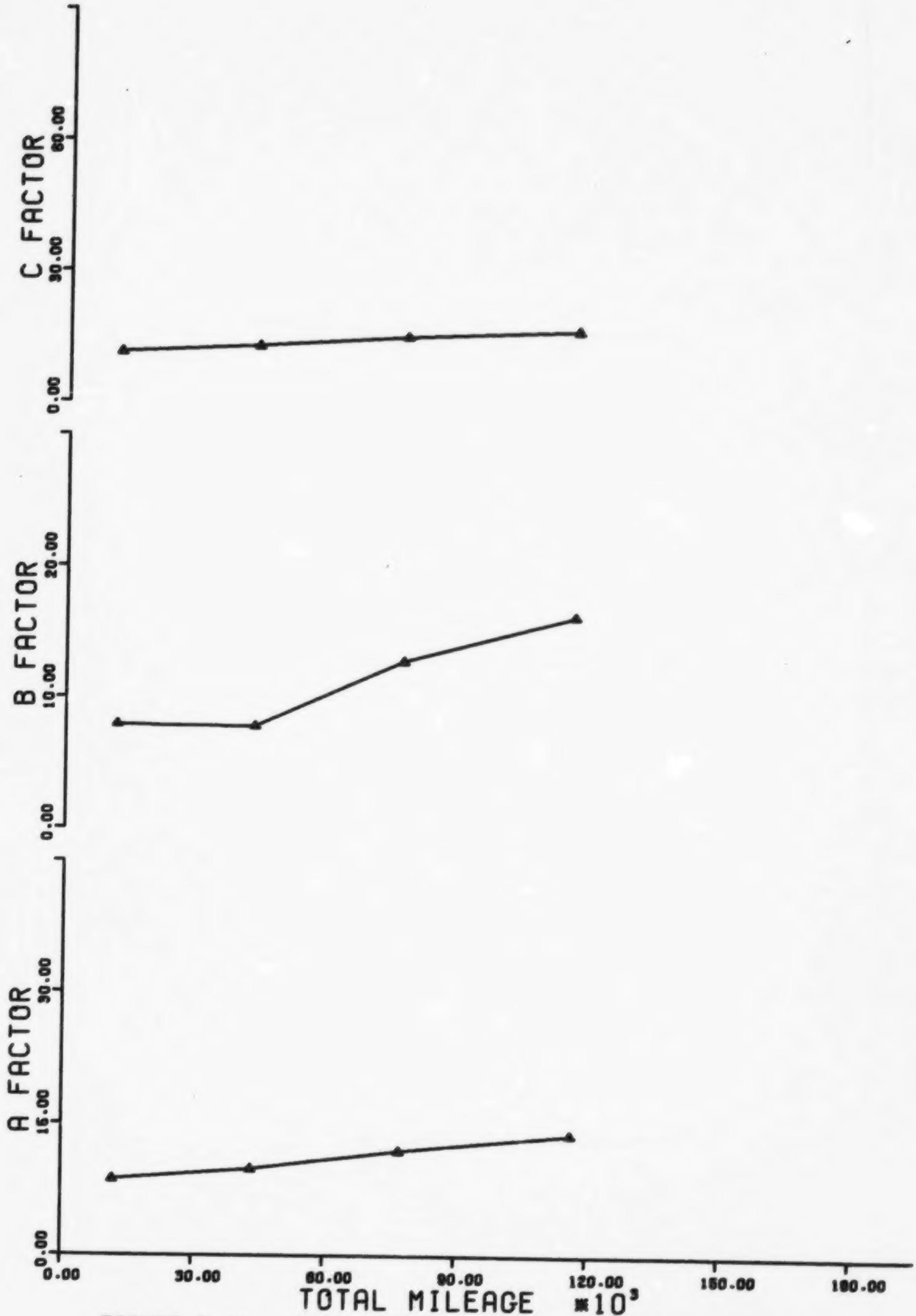

FIGURE D-41. UNIT 970 CUMMINS V-903

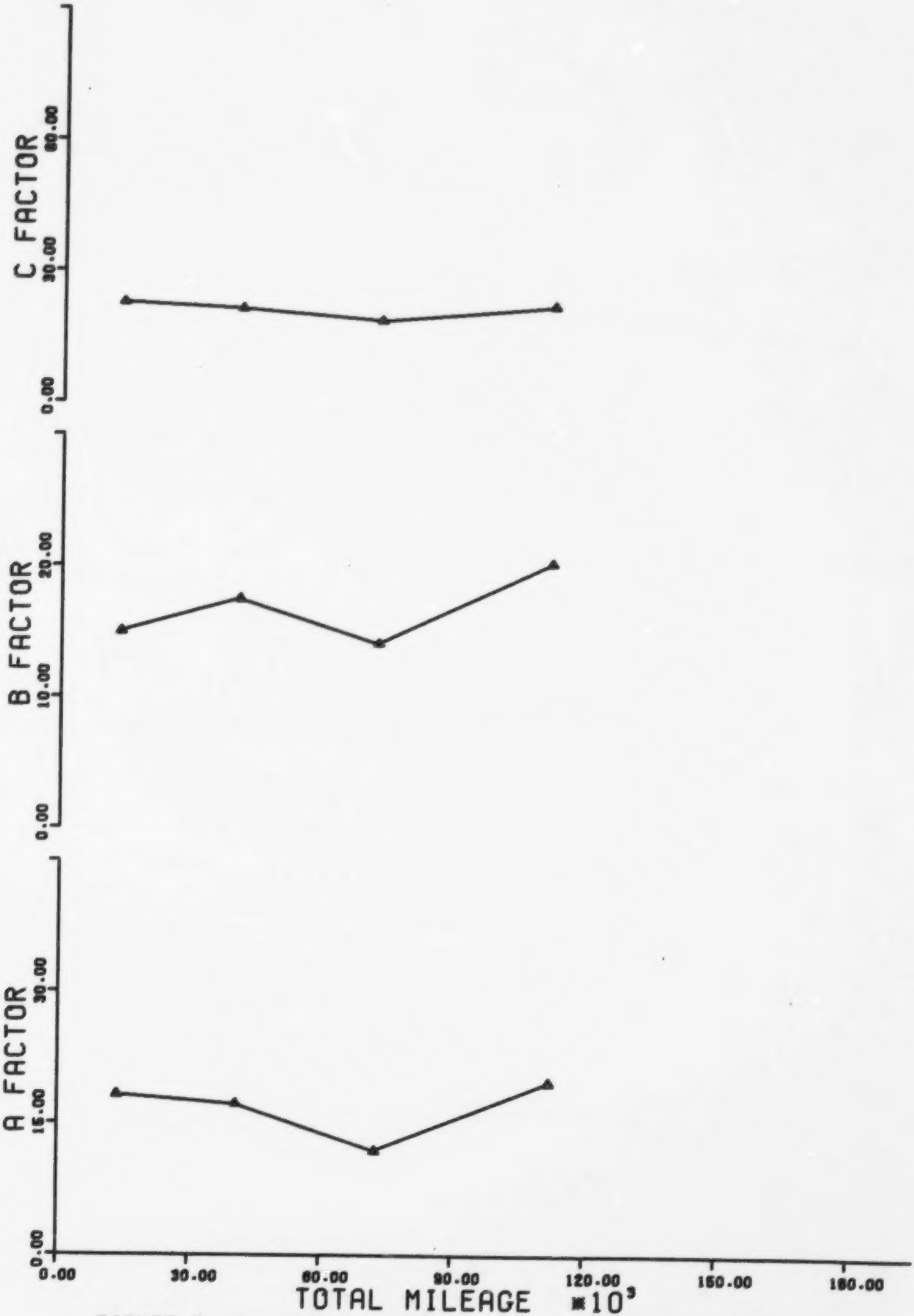

FIGURE D-42. UNIT 972 CUMMINS V-903

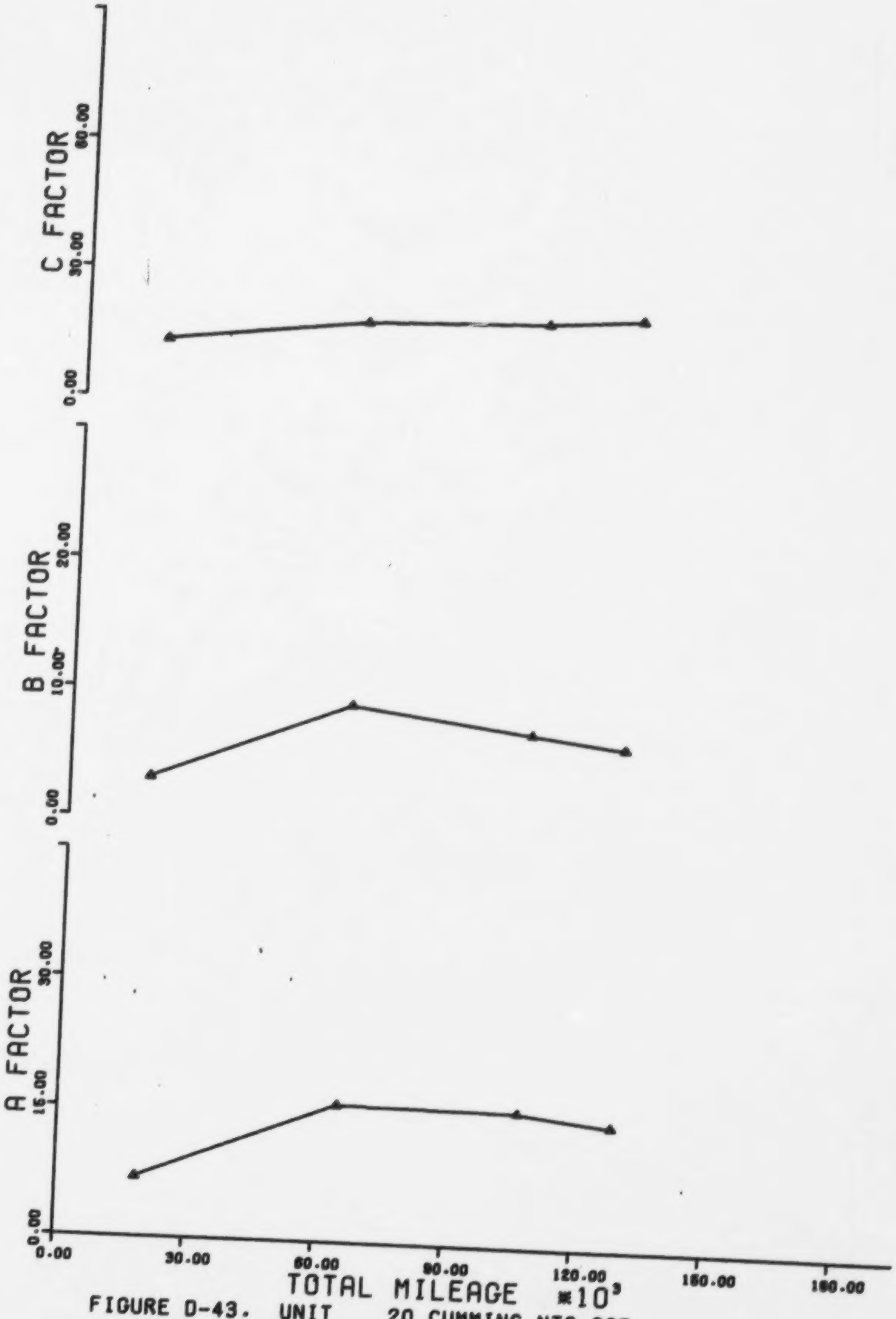

FIGURE D-43. UNIT 20 CUMMINS NTC-335

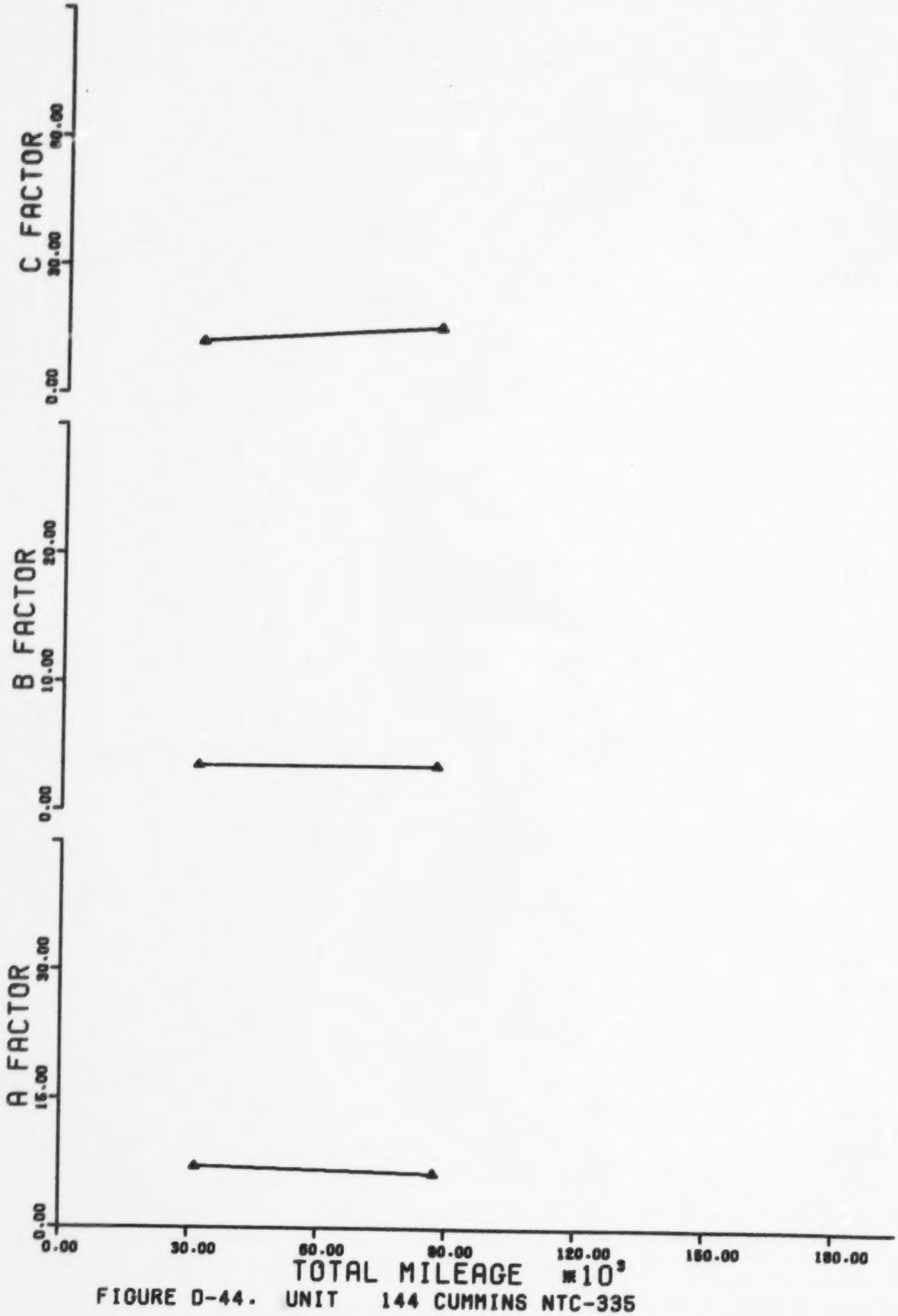

FIGURE D-44. UNIT 144 CUMMINS NTC-335

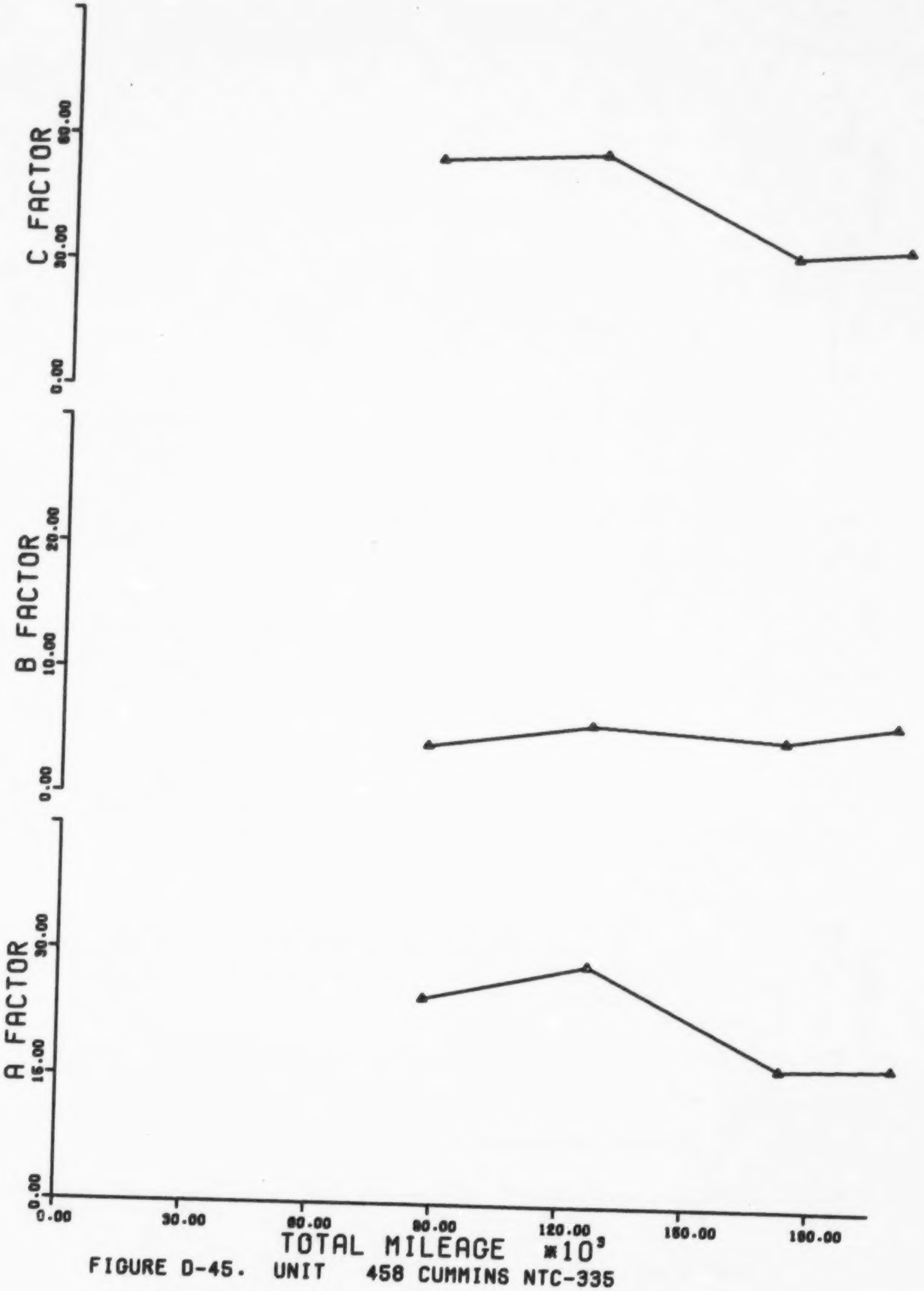

FIGURE D-45. UNIT 458 CUMMINS NTC-335

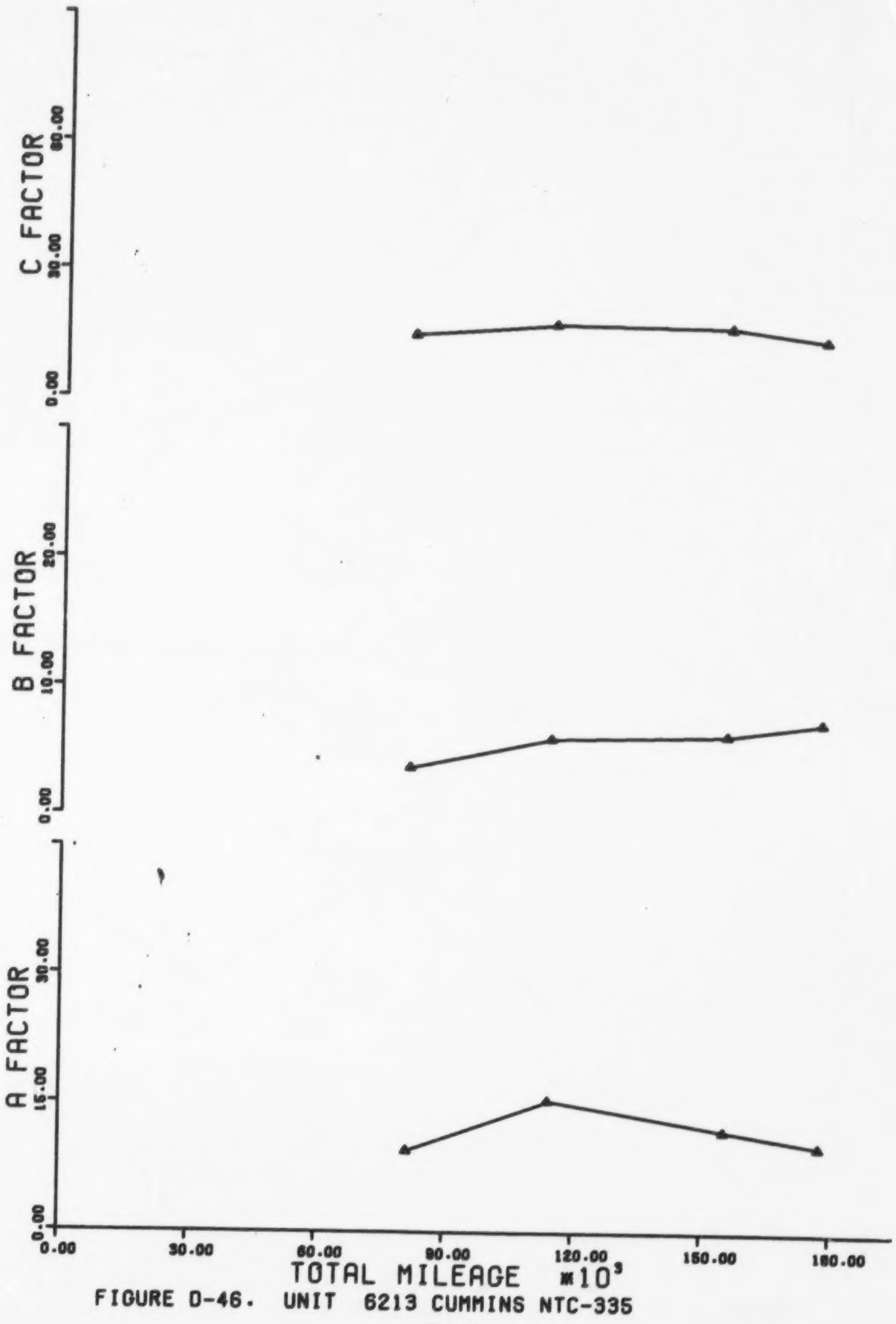

FIGURE D-46. UNIT 6213 CUMMINS NTC-335

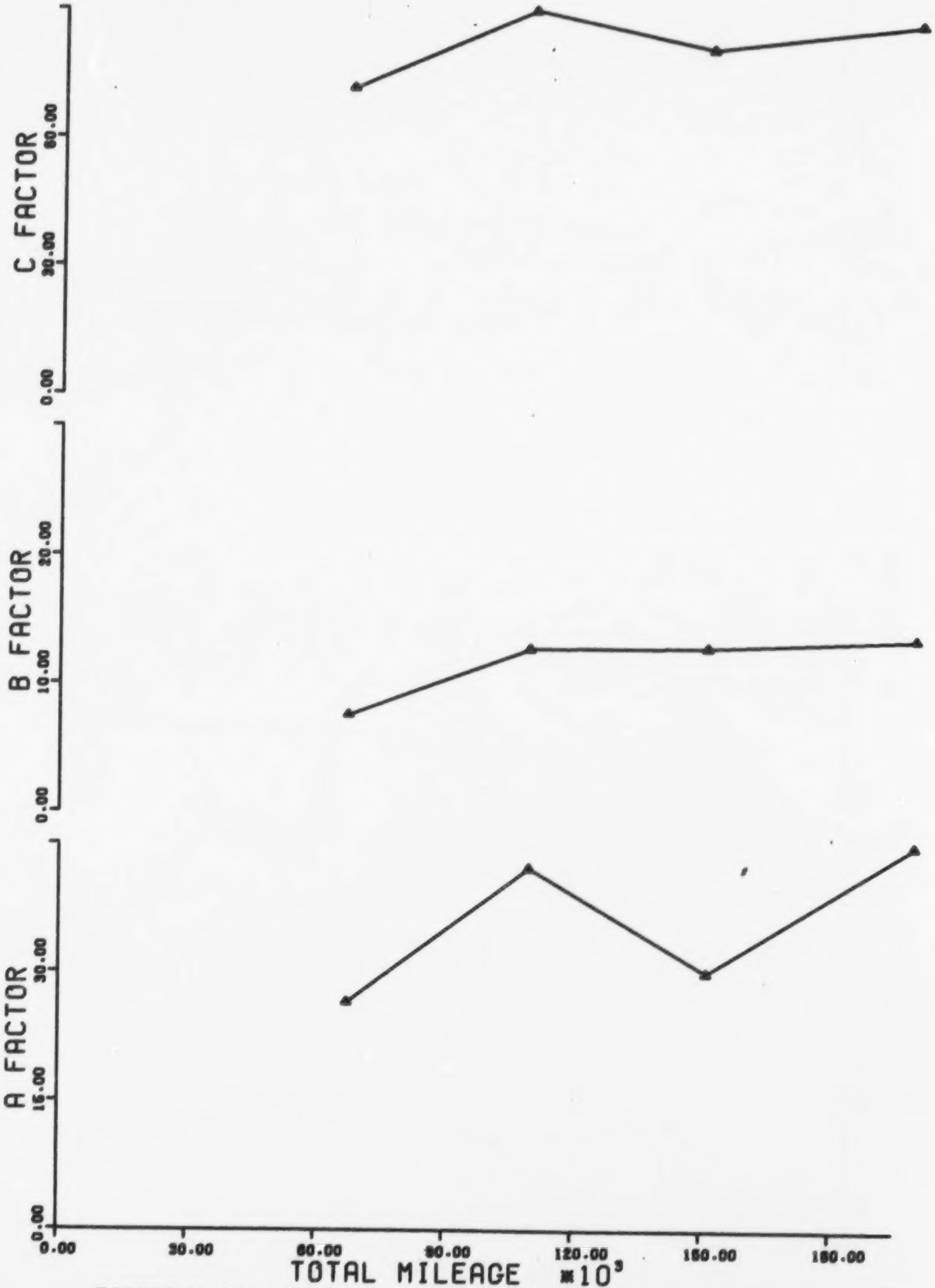

FIGURE D-47. UNIT 1 MACK ENDT 675

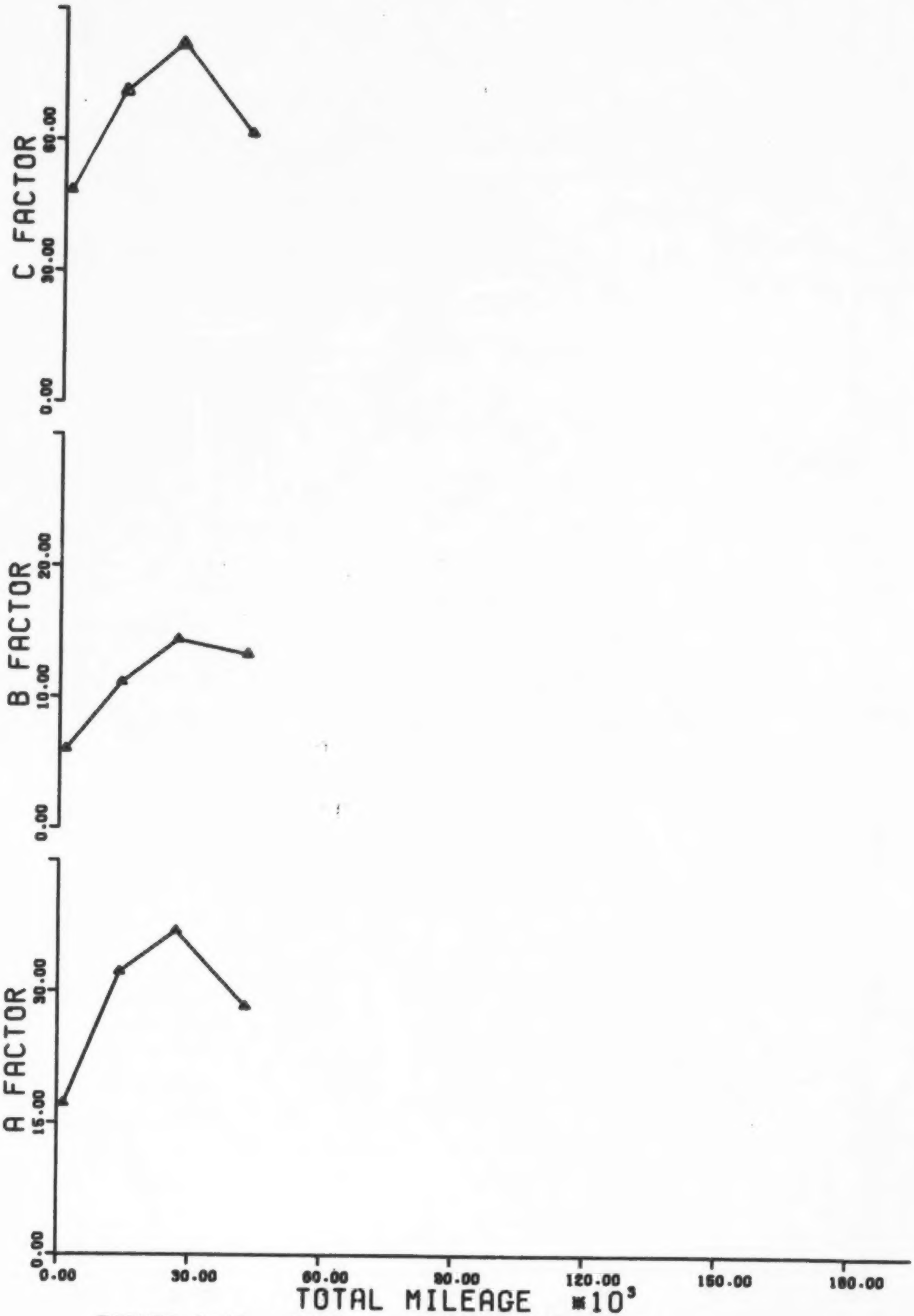

FIGURE D-48. UNIT 2 MACK ENDT 675

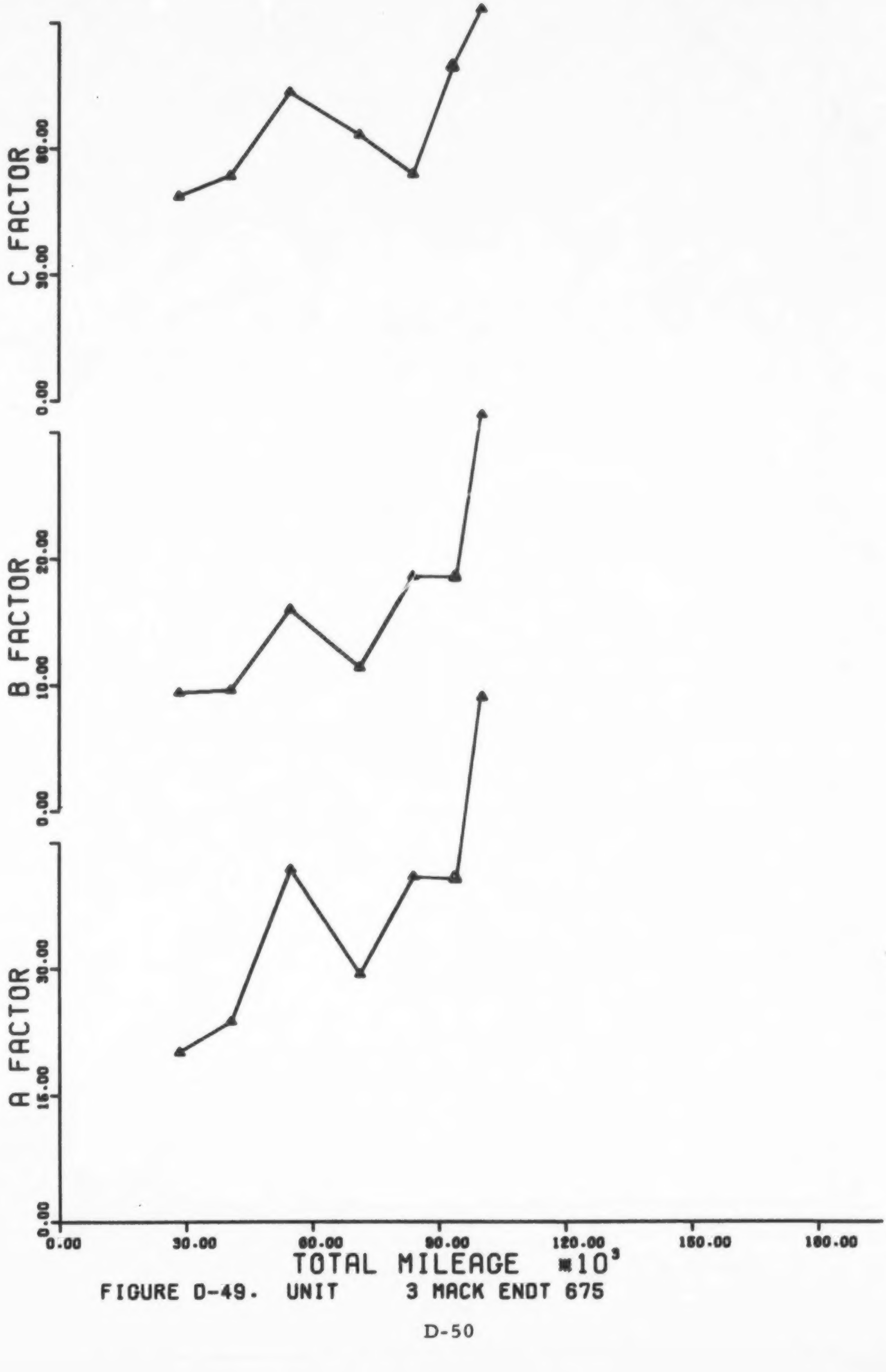

FIGURE D-49. UNIT 3 MACK ENDT 675

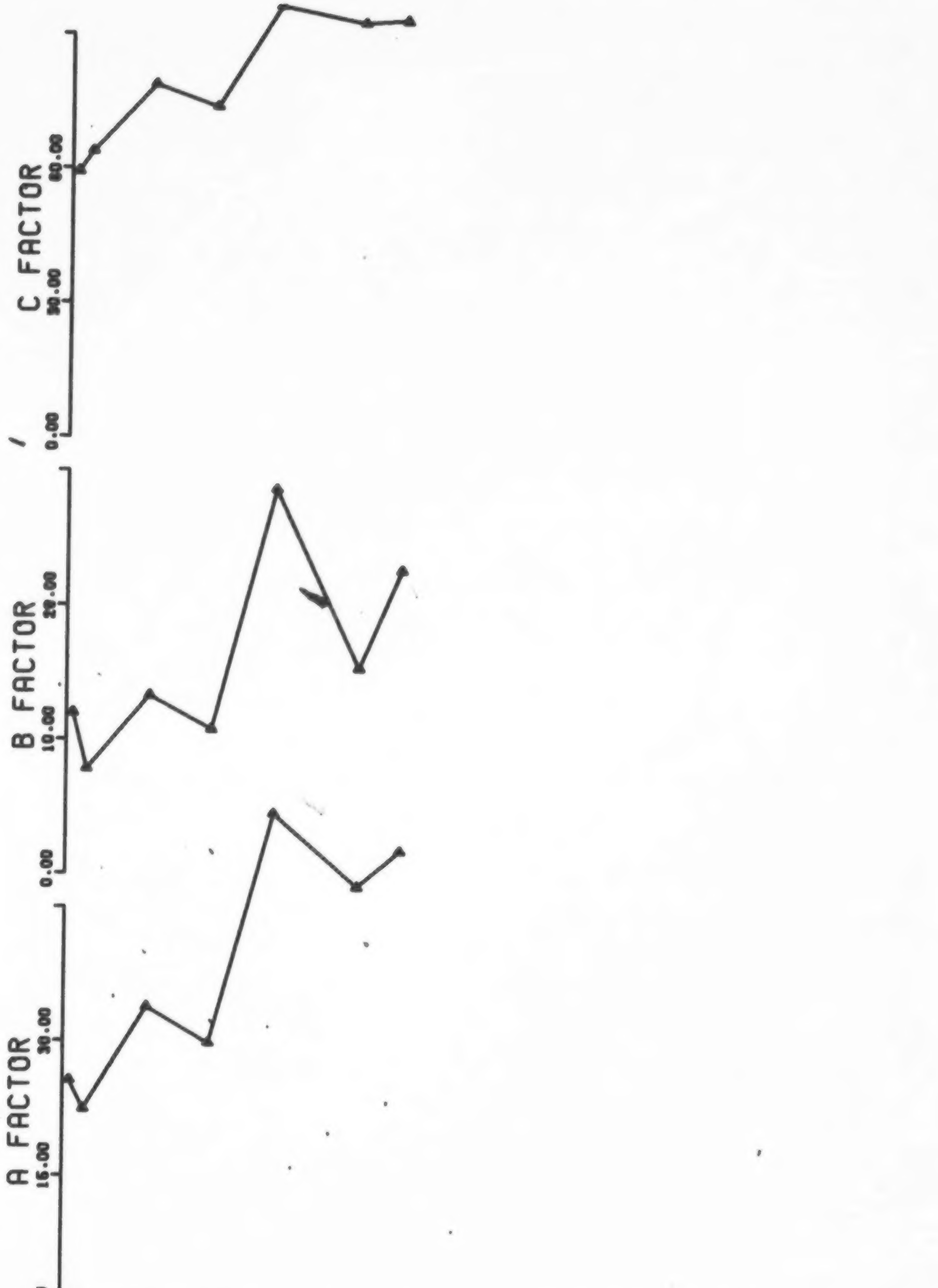

FIGURE D-50. UNIT 4 MACK ENDT 675

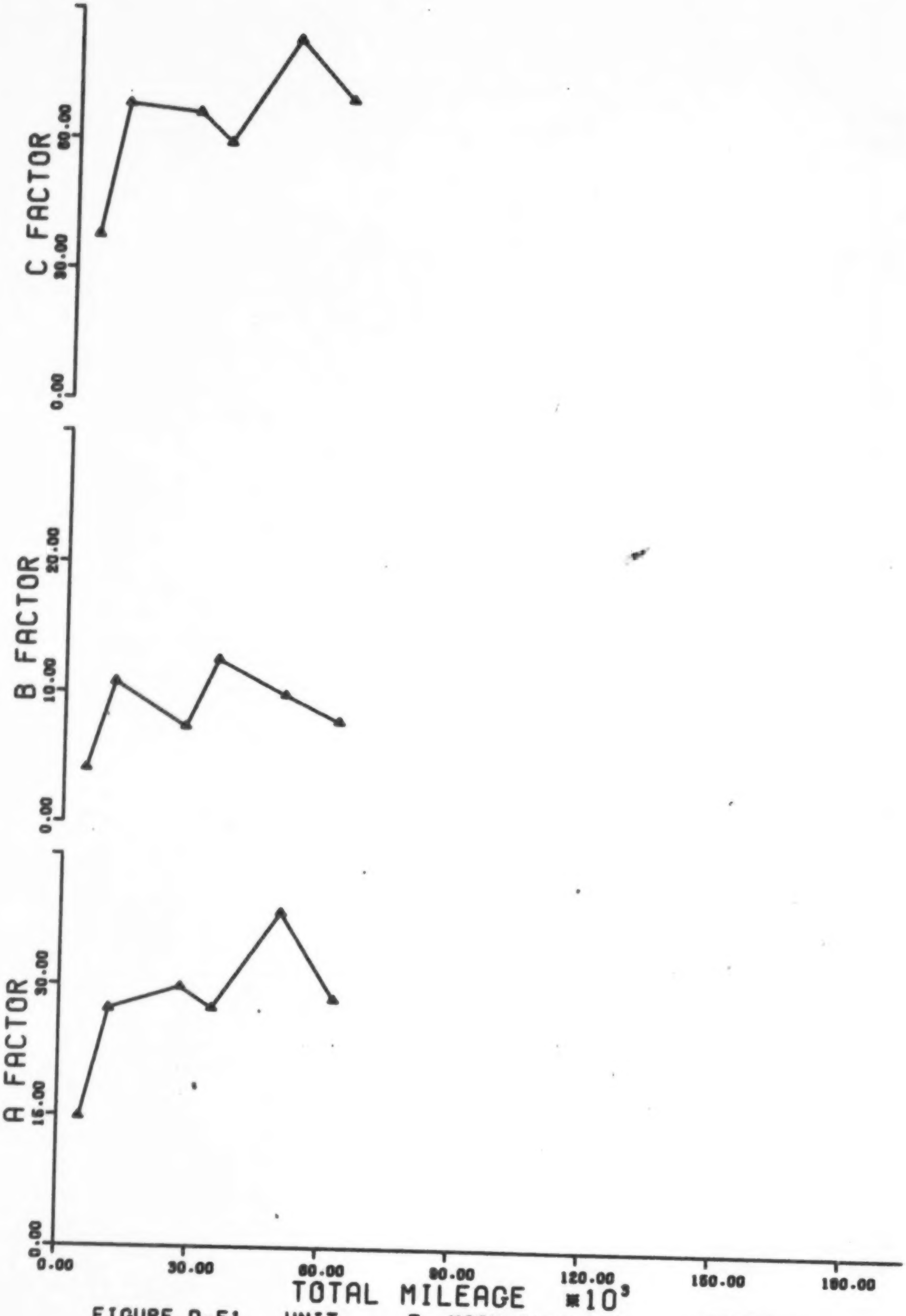

FIGURE D-51. UNIT 5 MACK ENDT 675 SOURCE 1

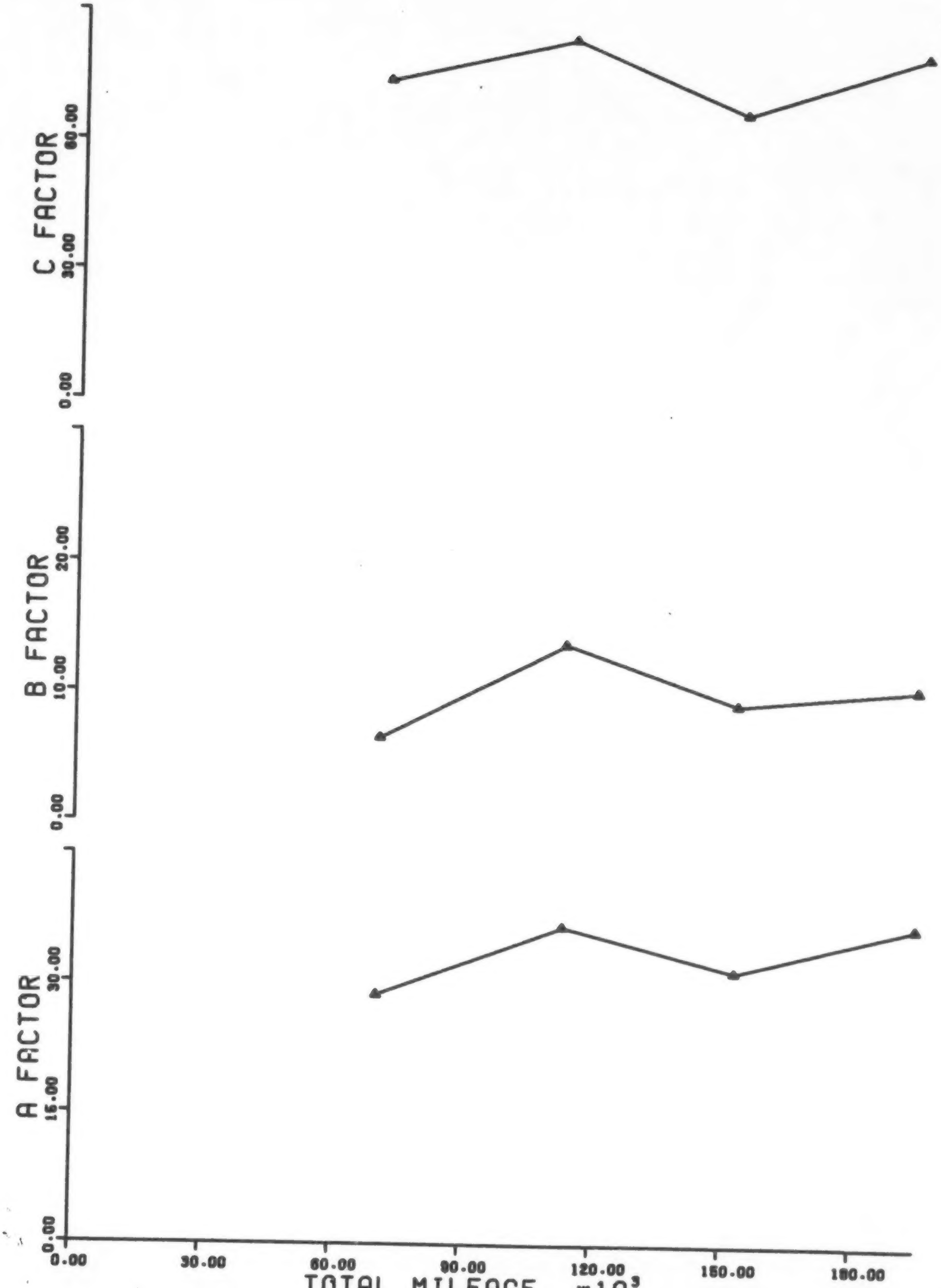

FIGURE D-52. UNIT 5 MACK ENDT 675 SOURCE 2

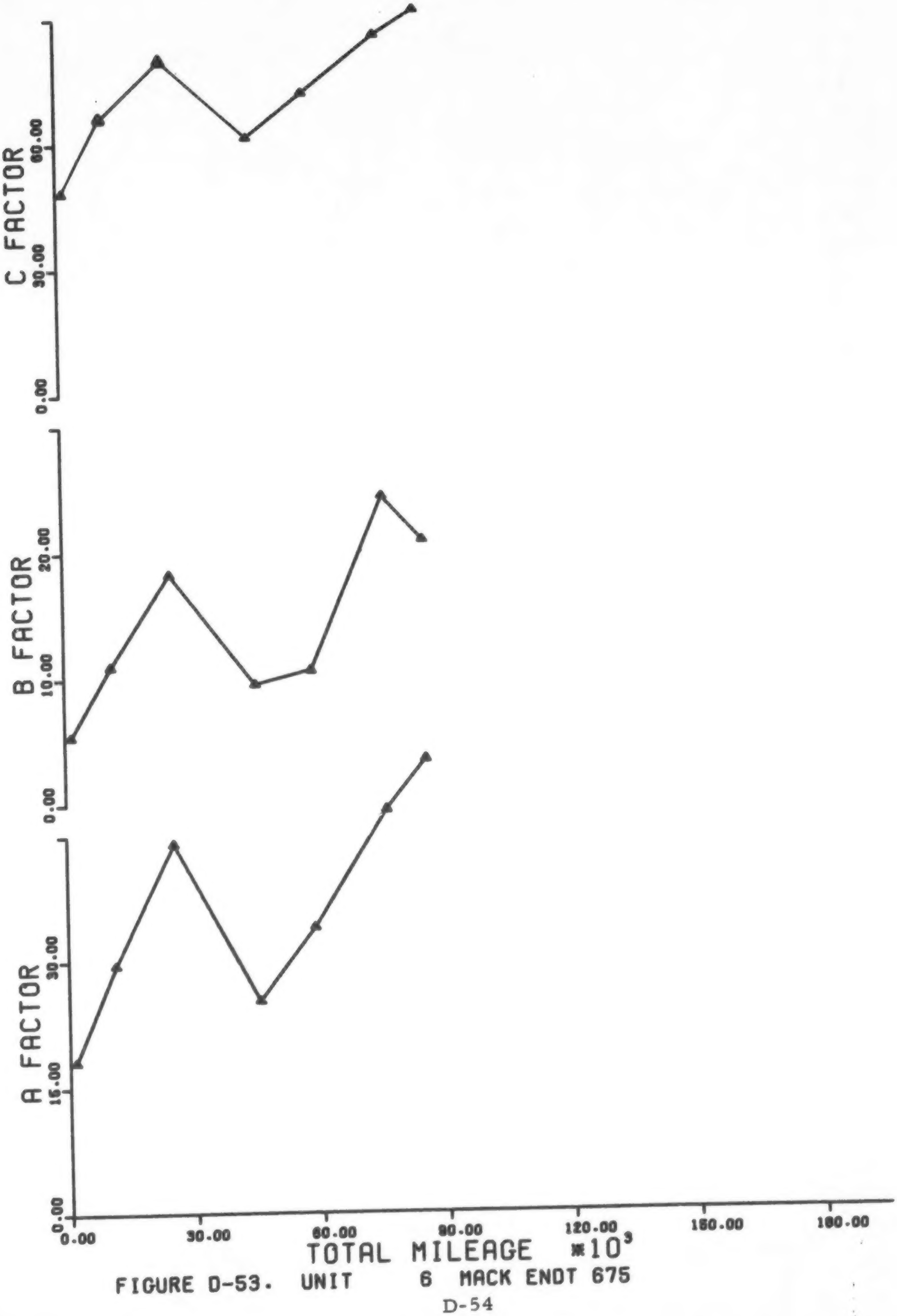

FIGURE D-53. UNIT 6 MACK ENDT 675

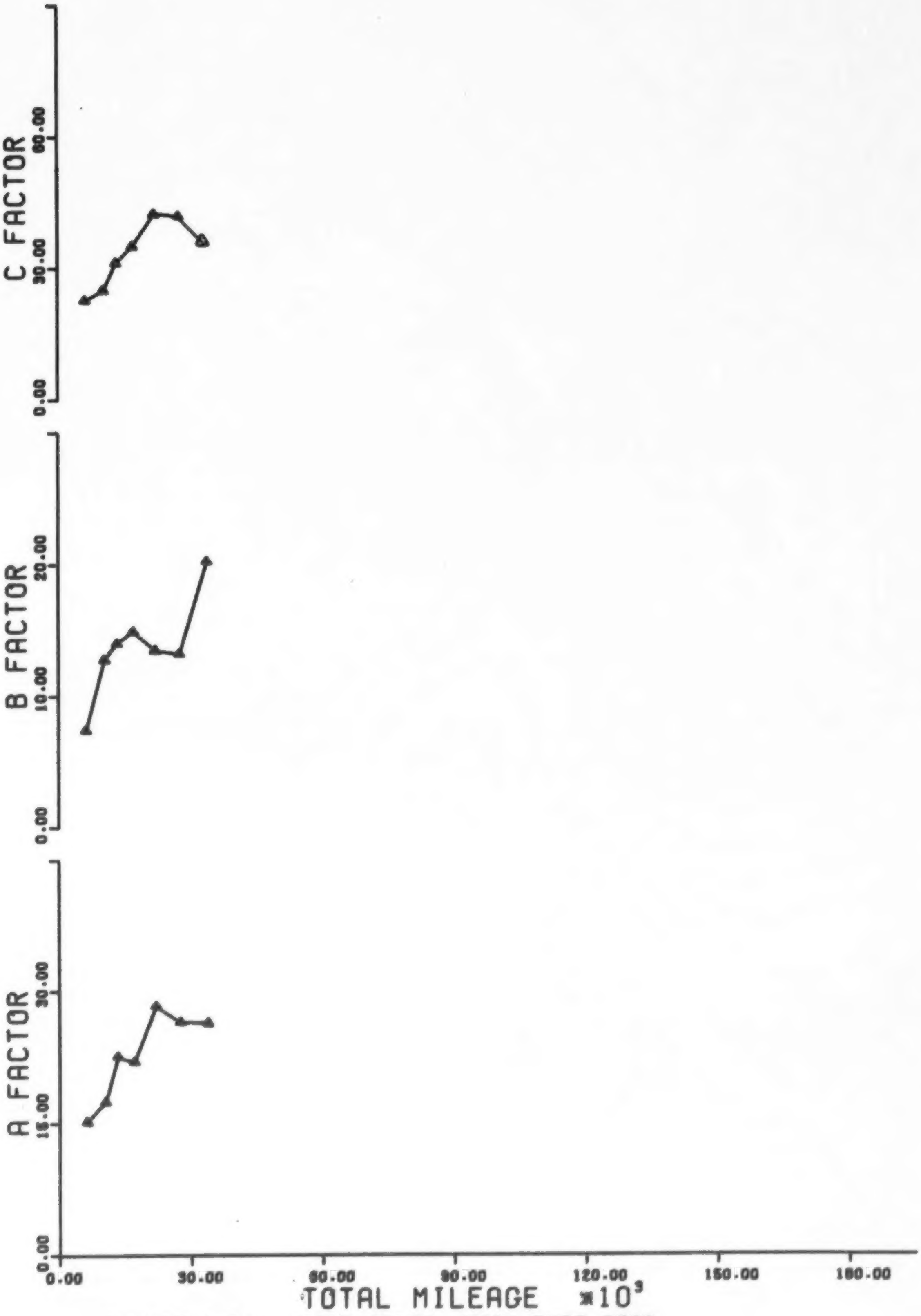

FIGURE D-54. UNIT 60122 MACK ENDT 673B

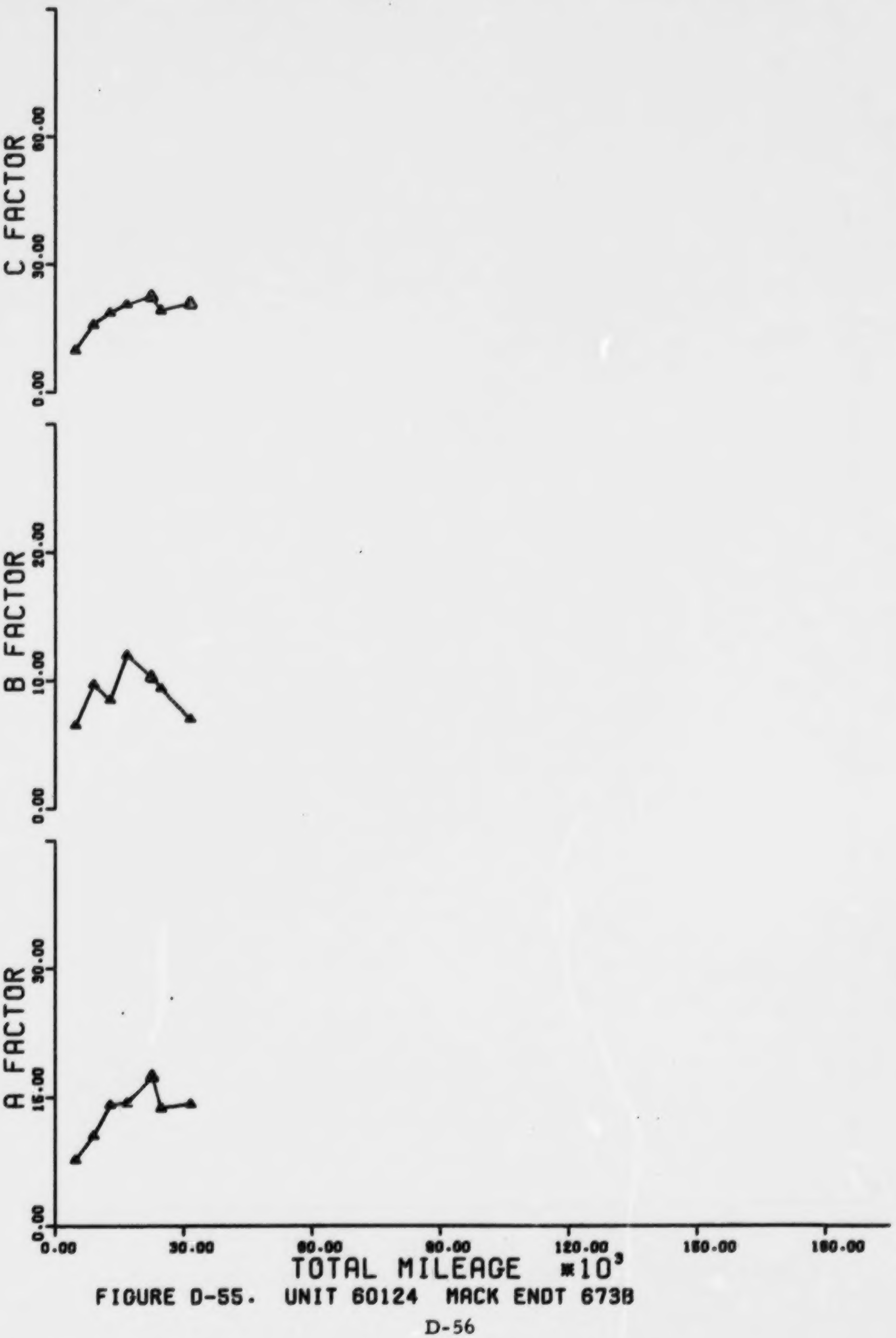

FIGURE D-55. UNIT 60124 MACK ENDT 673B

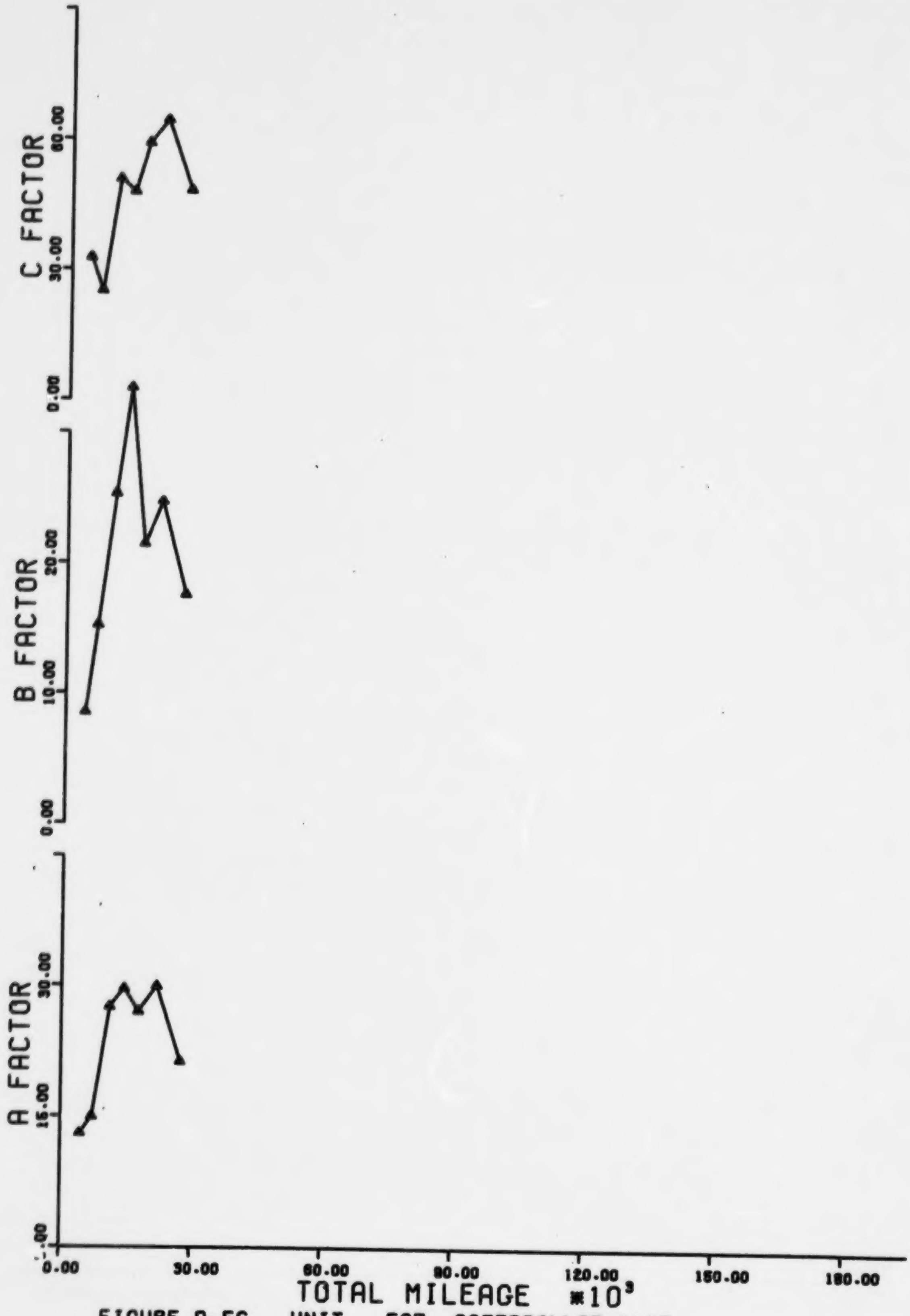

FIGURE D-56. UNIT 507 CATERPILLAR 1145

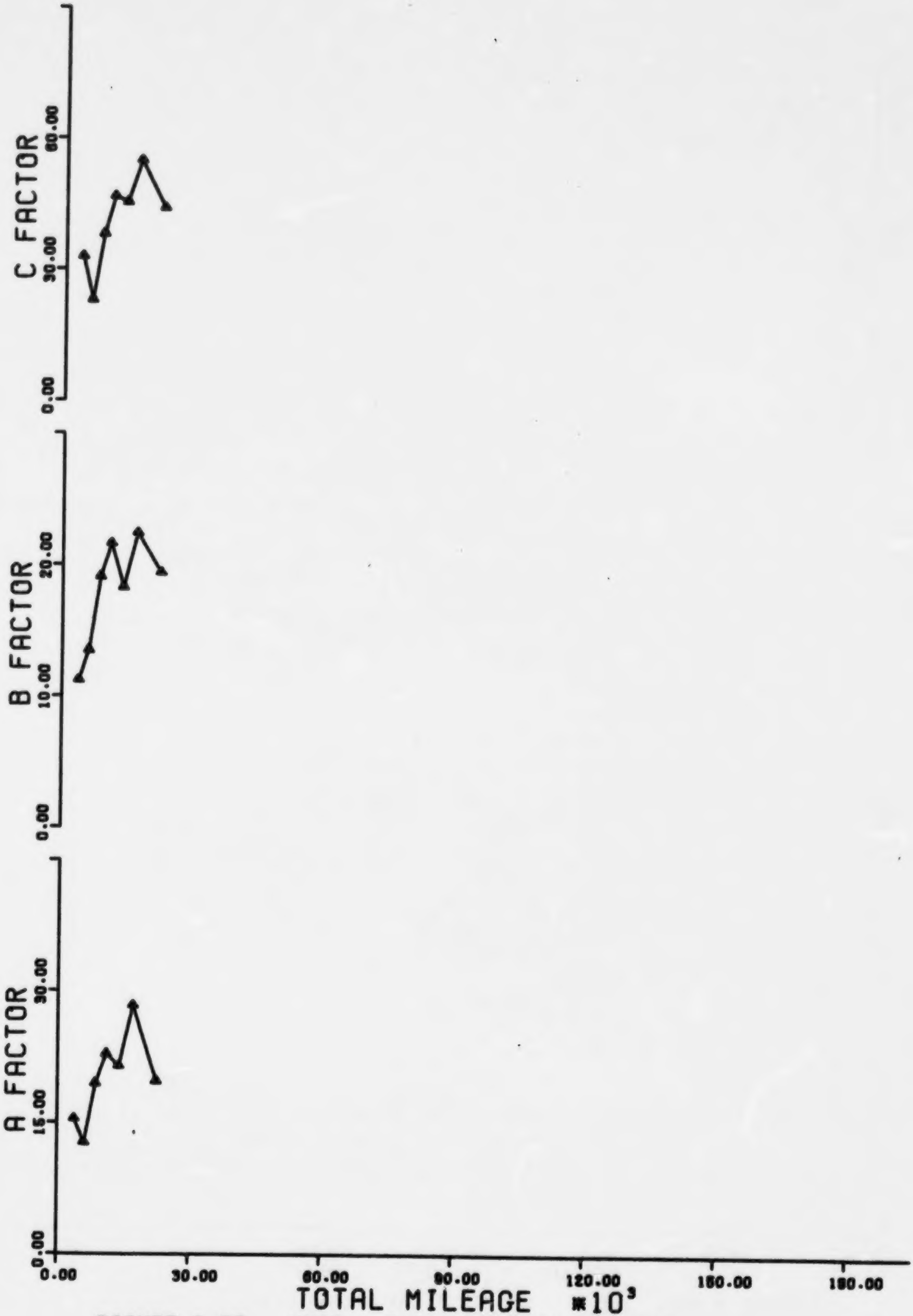

FIGURE D-57. UNIT 510 CATERPILLAR 1145

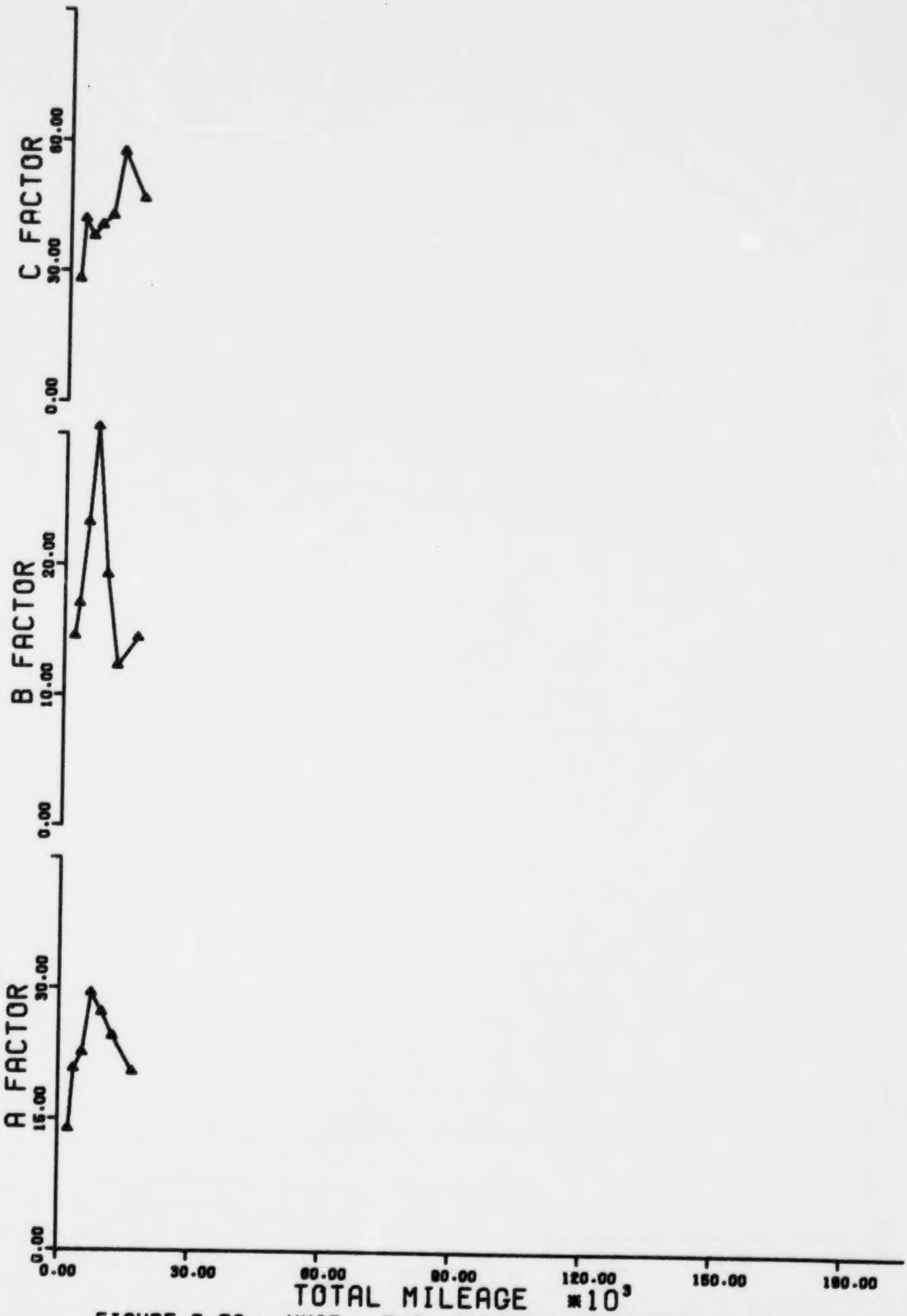

FIGURE D-58. UNIT 512 CATERPILLAR 1145

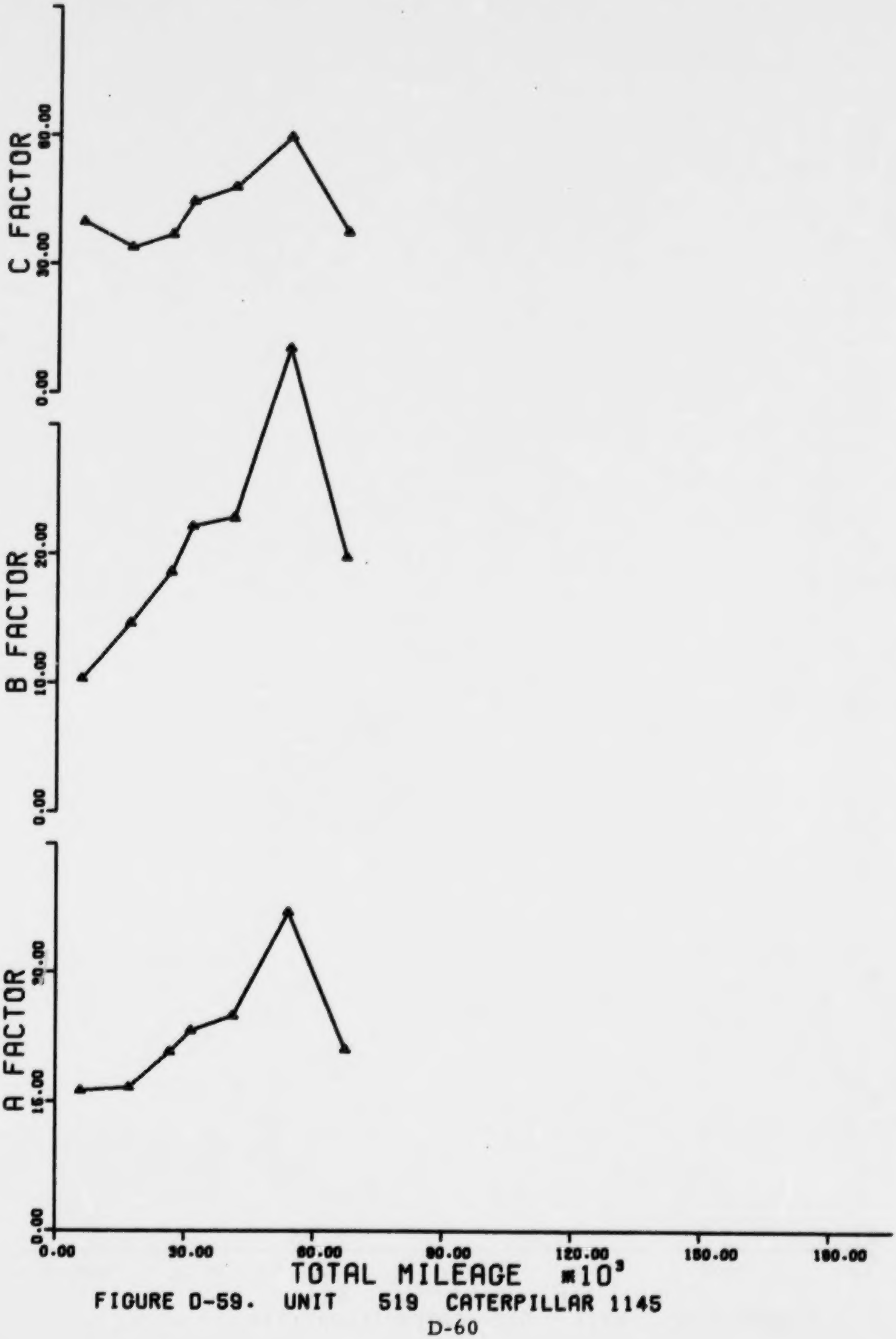

FIGURE D-59. UNIT 519 CATERPILLAR 1145

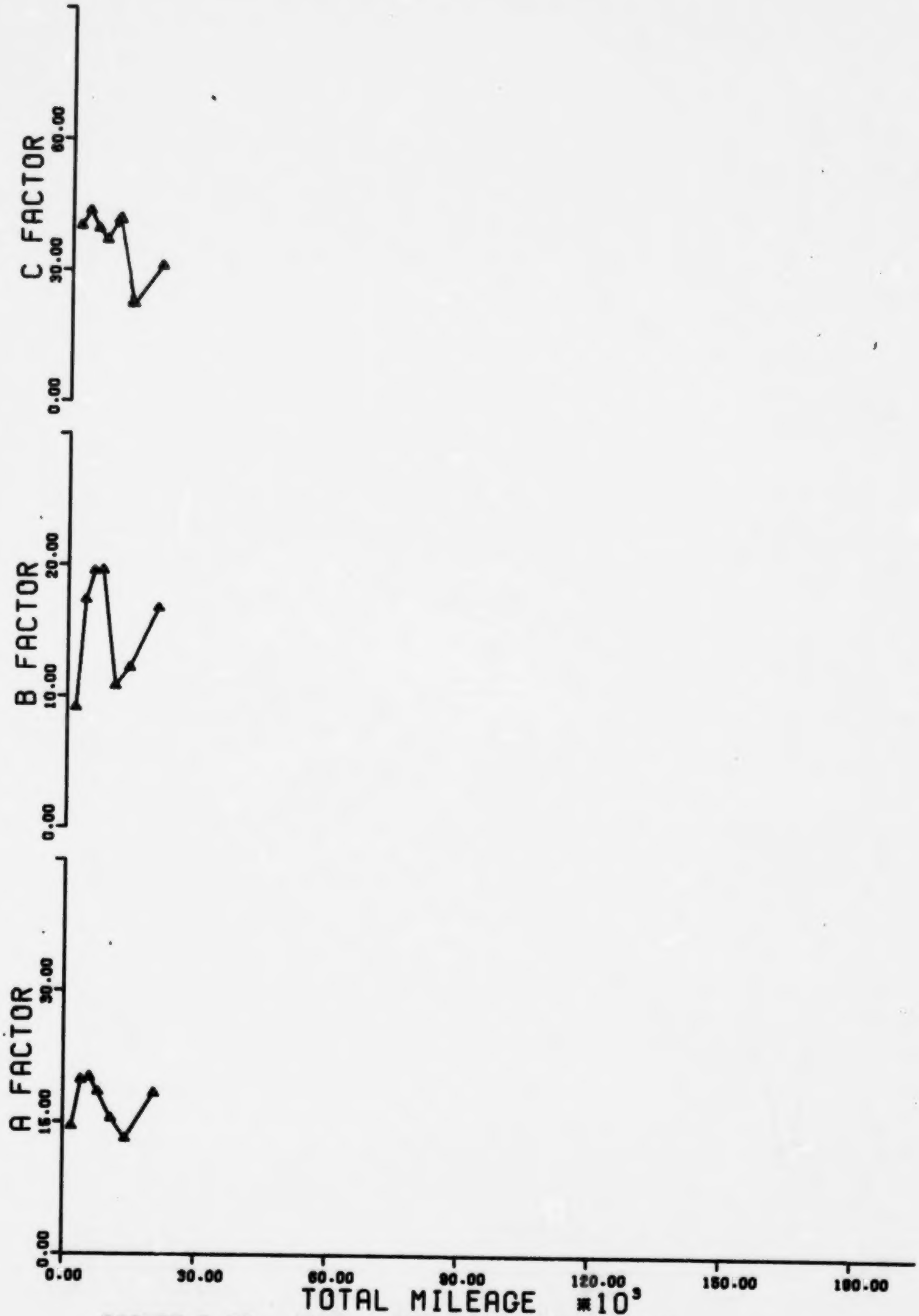

FIGURE D-60. UNIT 527 CATERPILLAR 1145

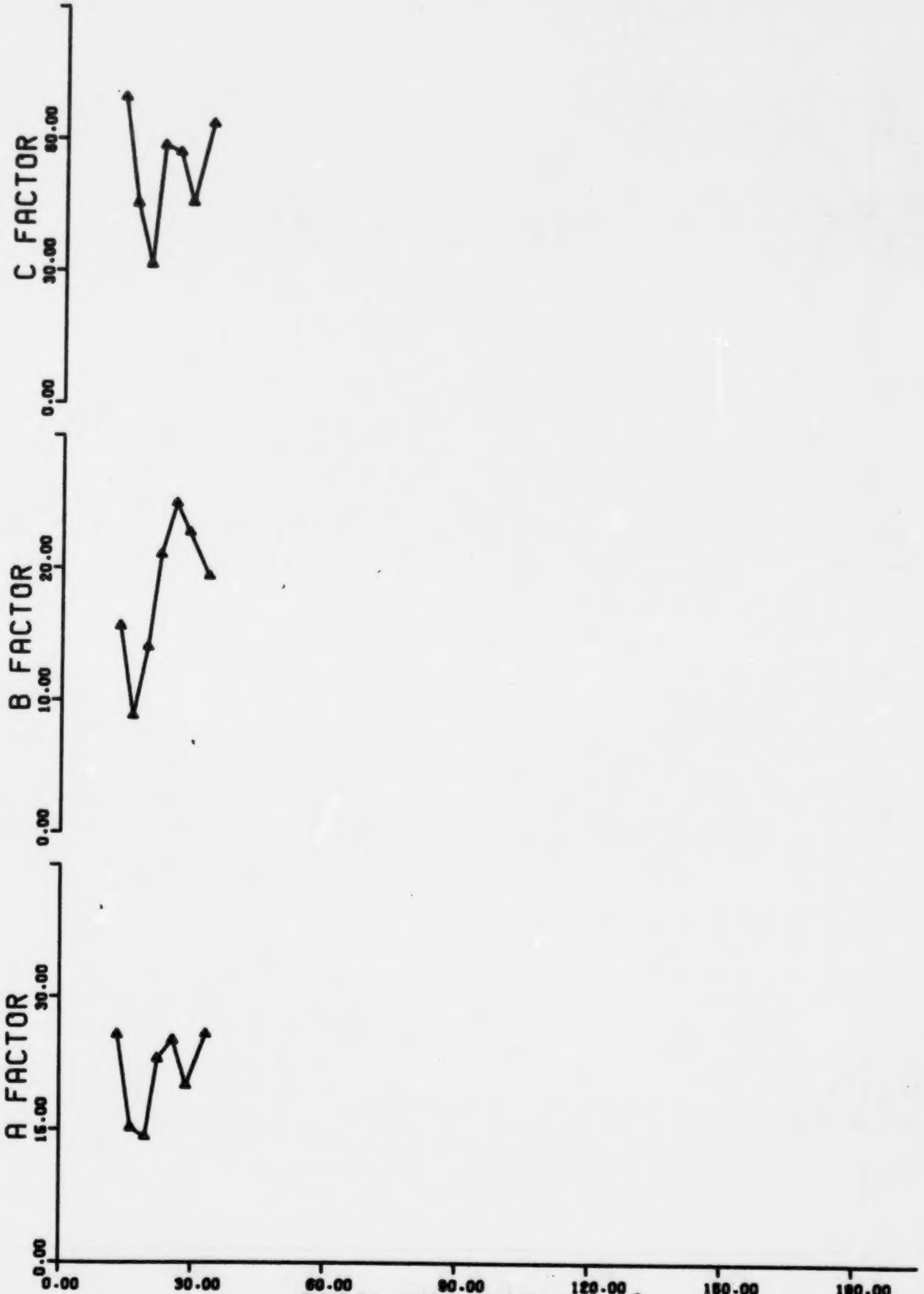

FIGURE D-61. UNIT 880 CATERPILLAR 1150

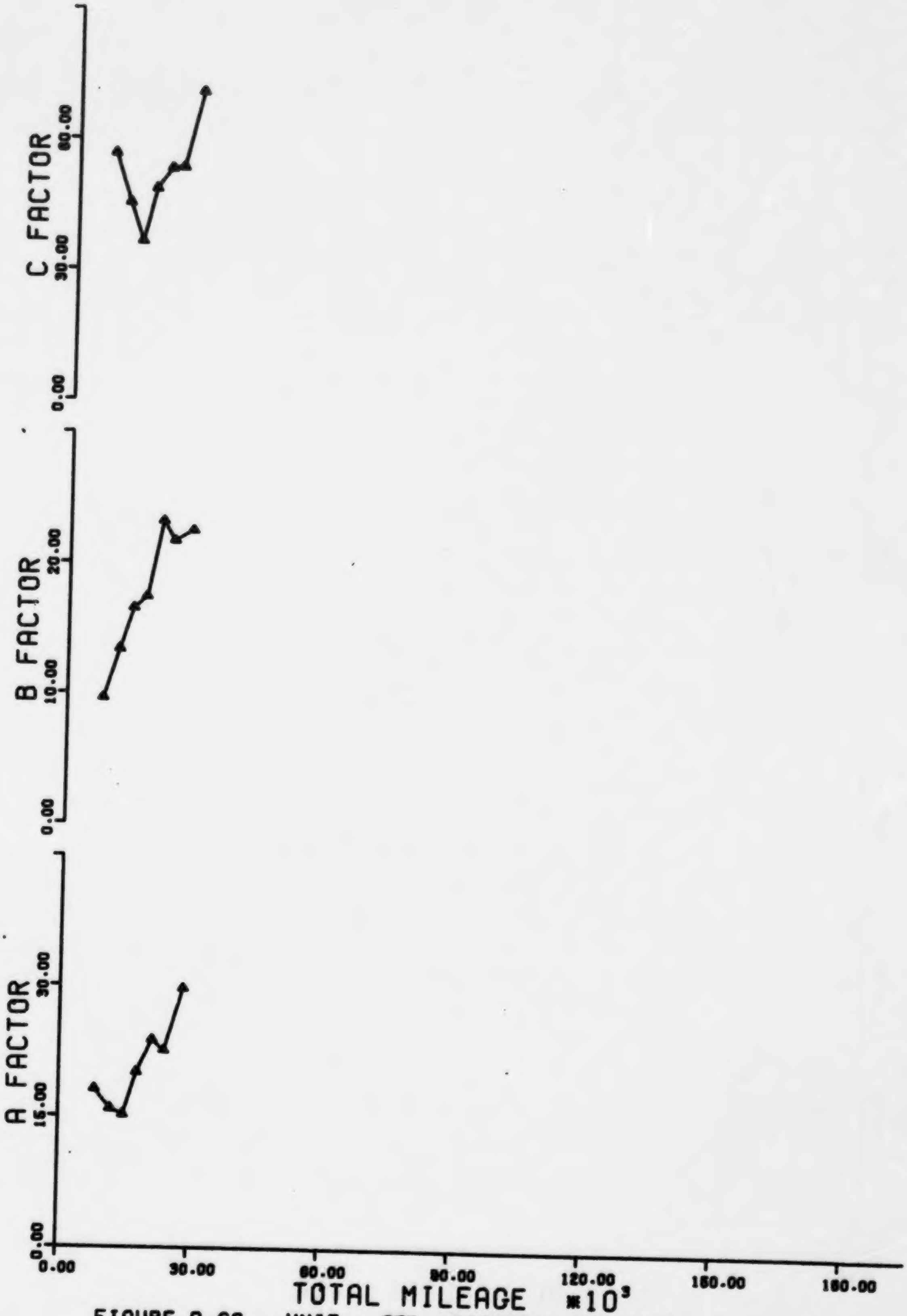

FIGURE D-62. UNIT 881 CATERPILLAR 1150

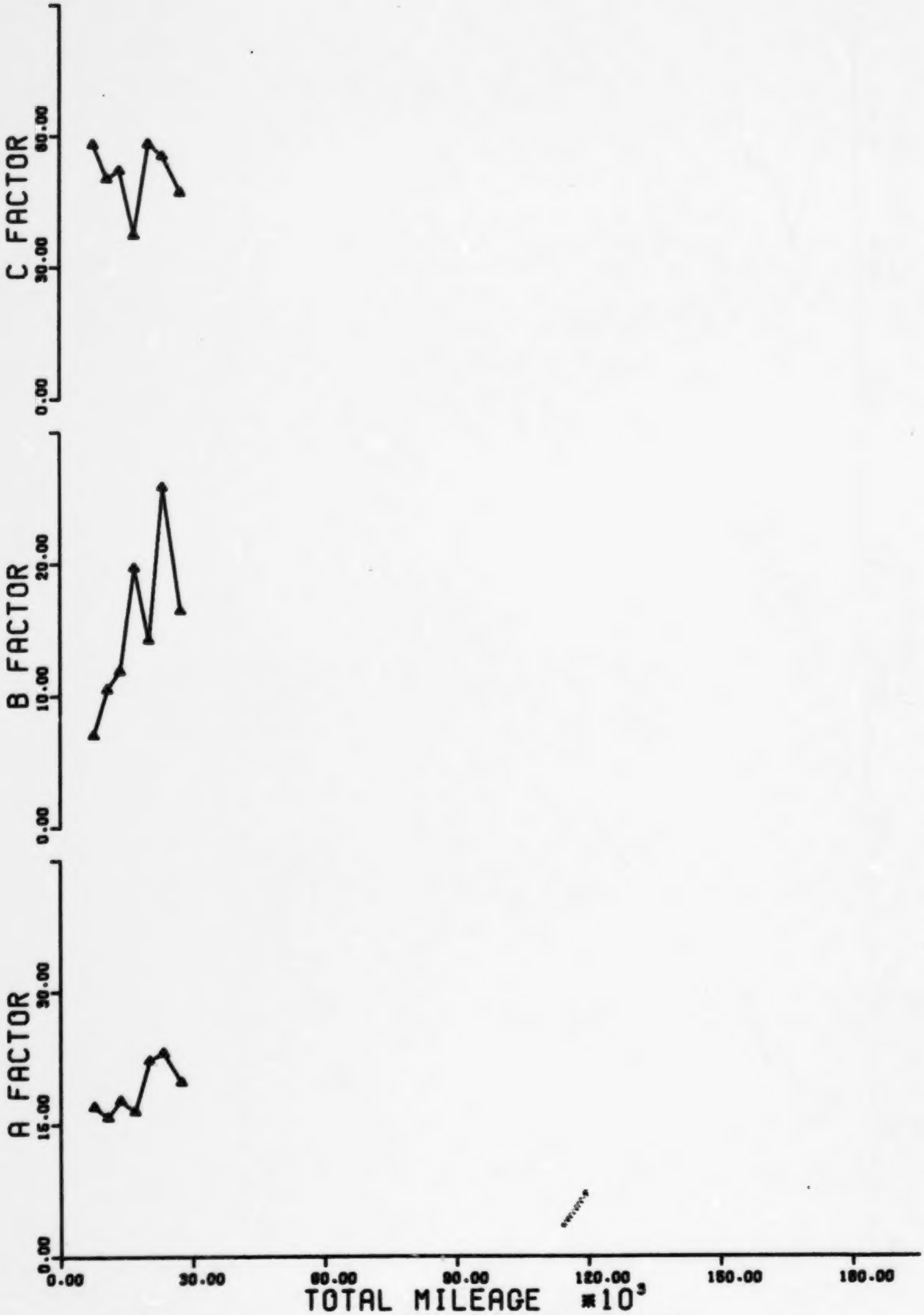

FIGURE D-63. UNIT 883 CATERPILLAR 1150

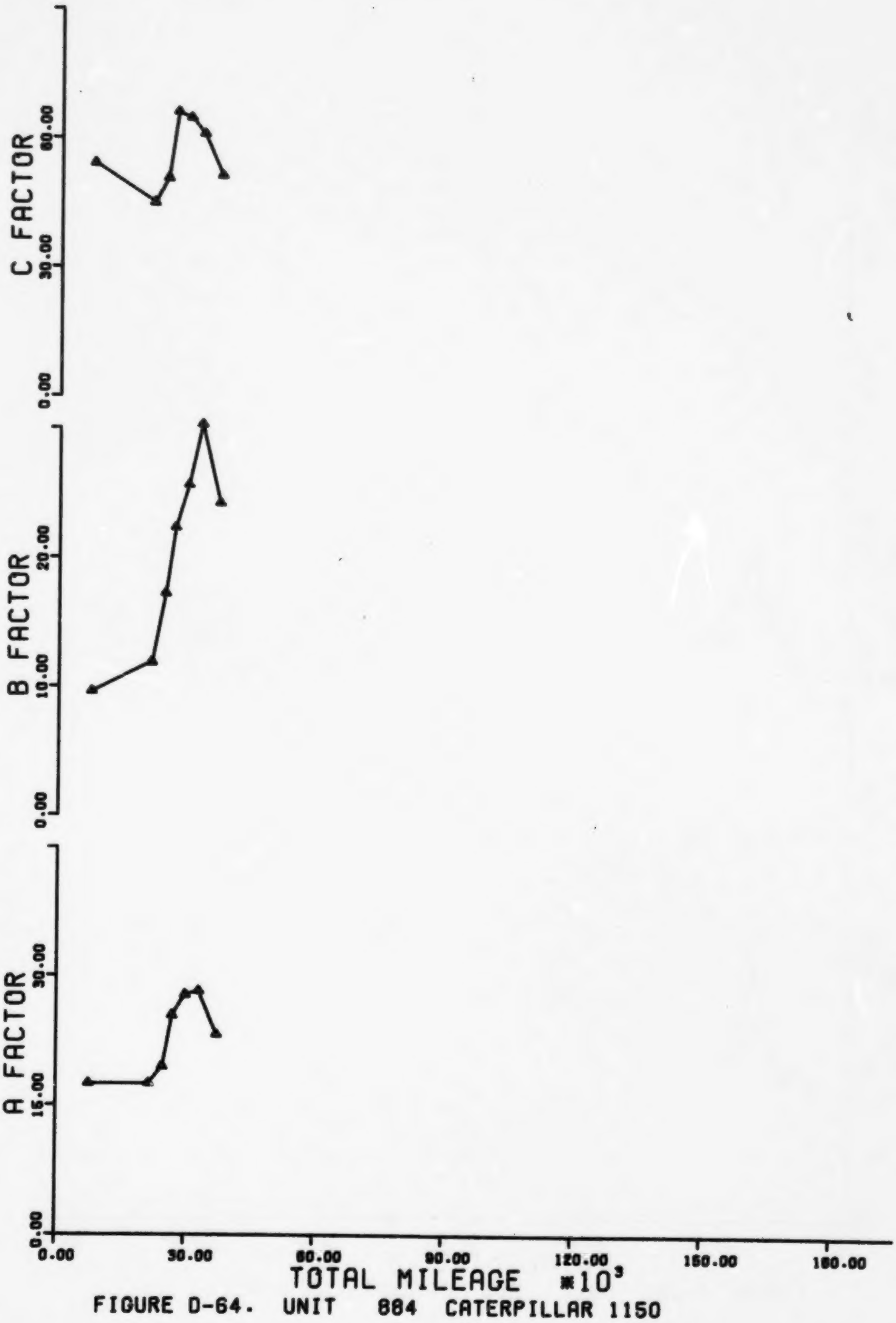

FIGURE D-64. UNIT 884 CATERPILLAR 1150

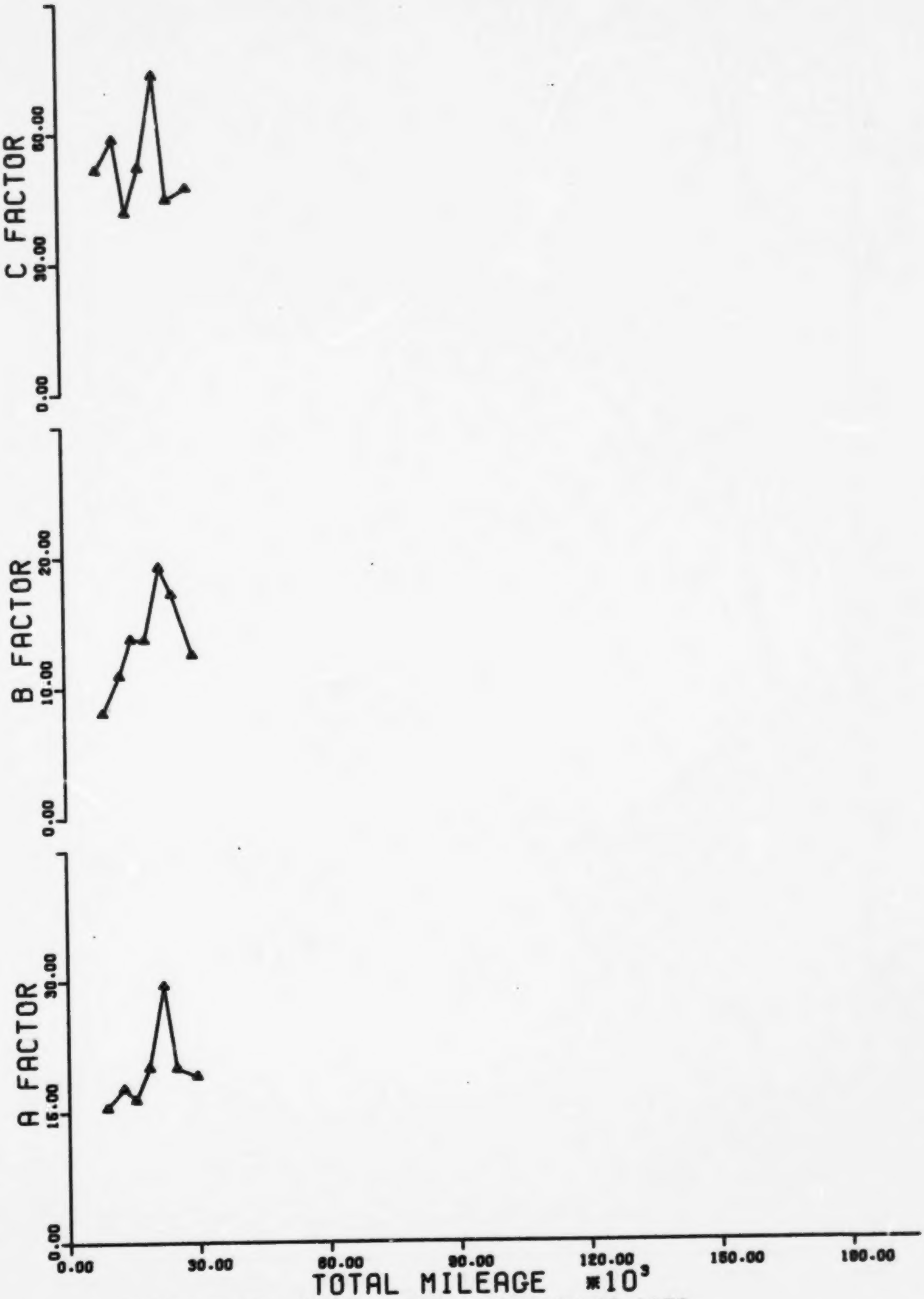

FIGURE D-65. UNIT 885 CATERPILLAR 1150

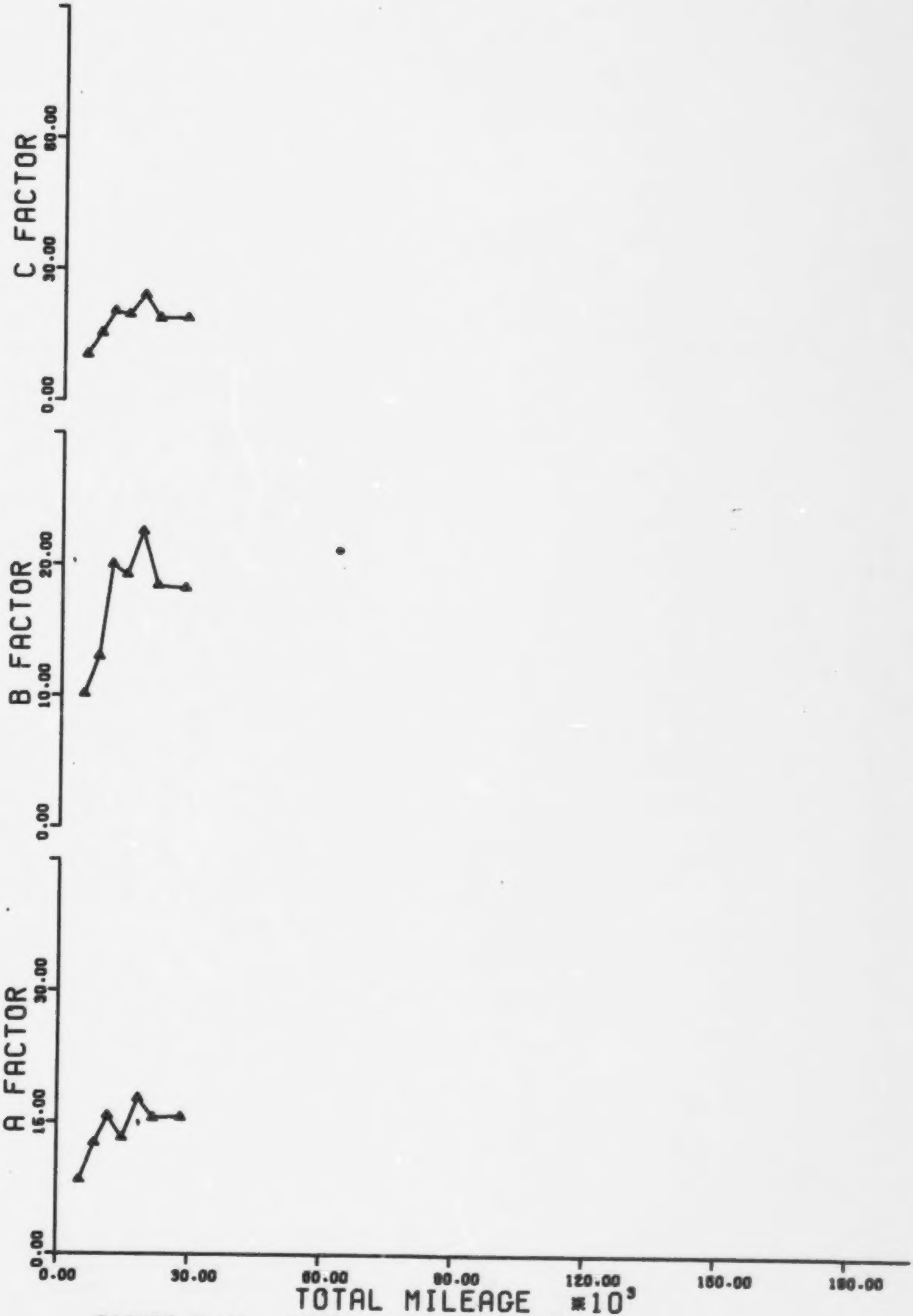

FIGURE D-66. UNIT 118 GM DH-478

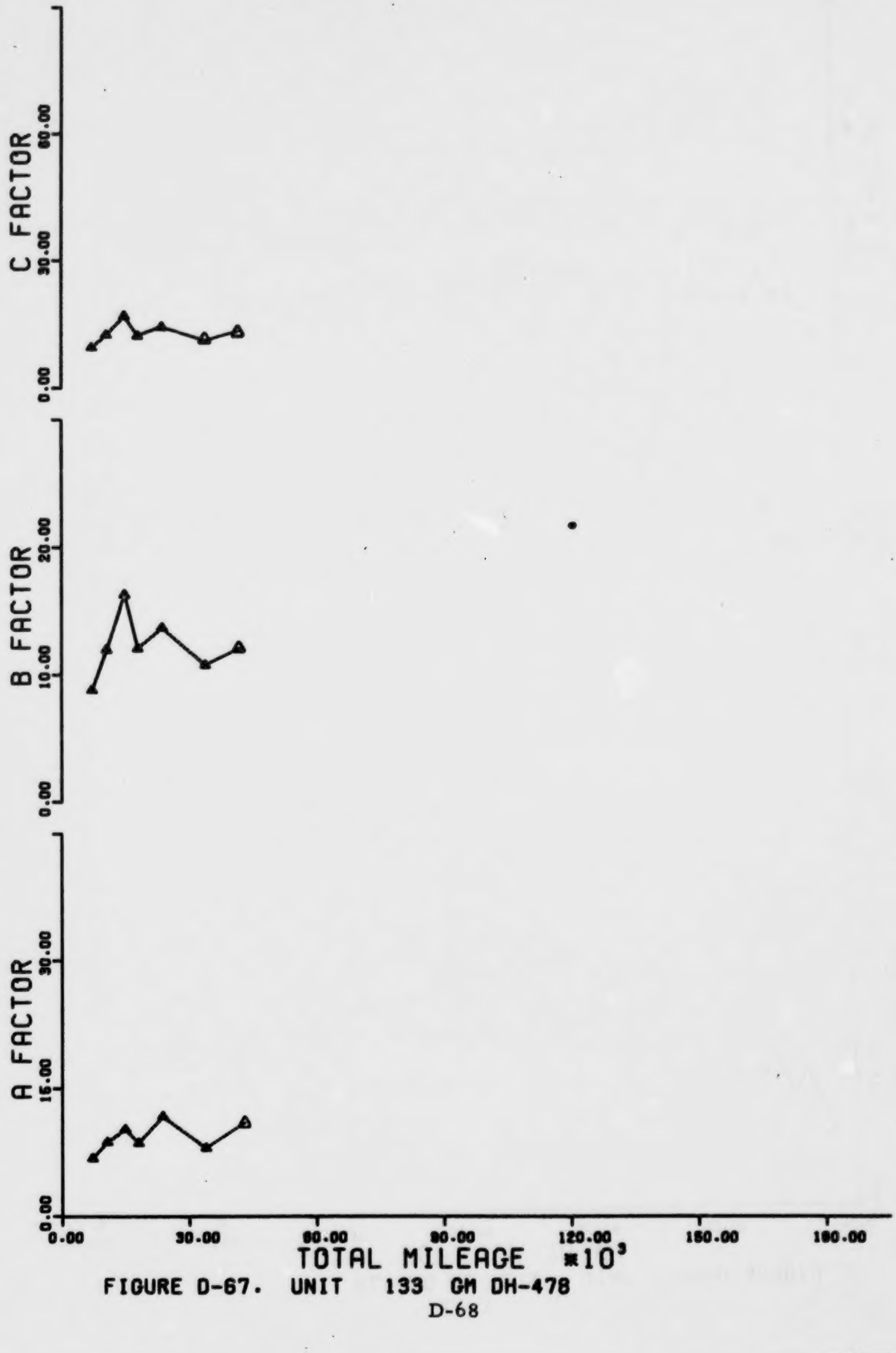

FIGURE D-67. UNIT 133 GM DH-478

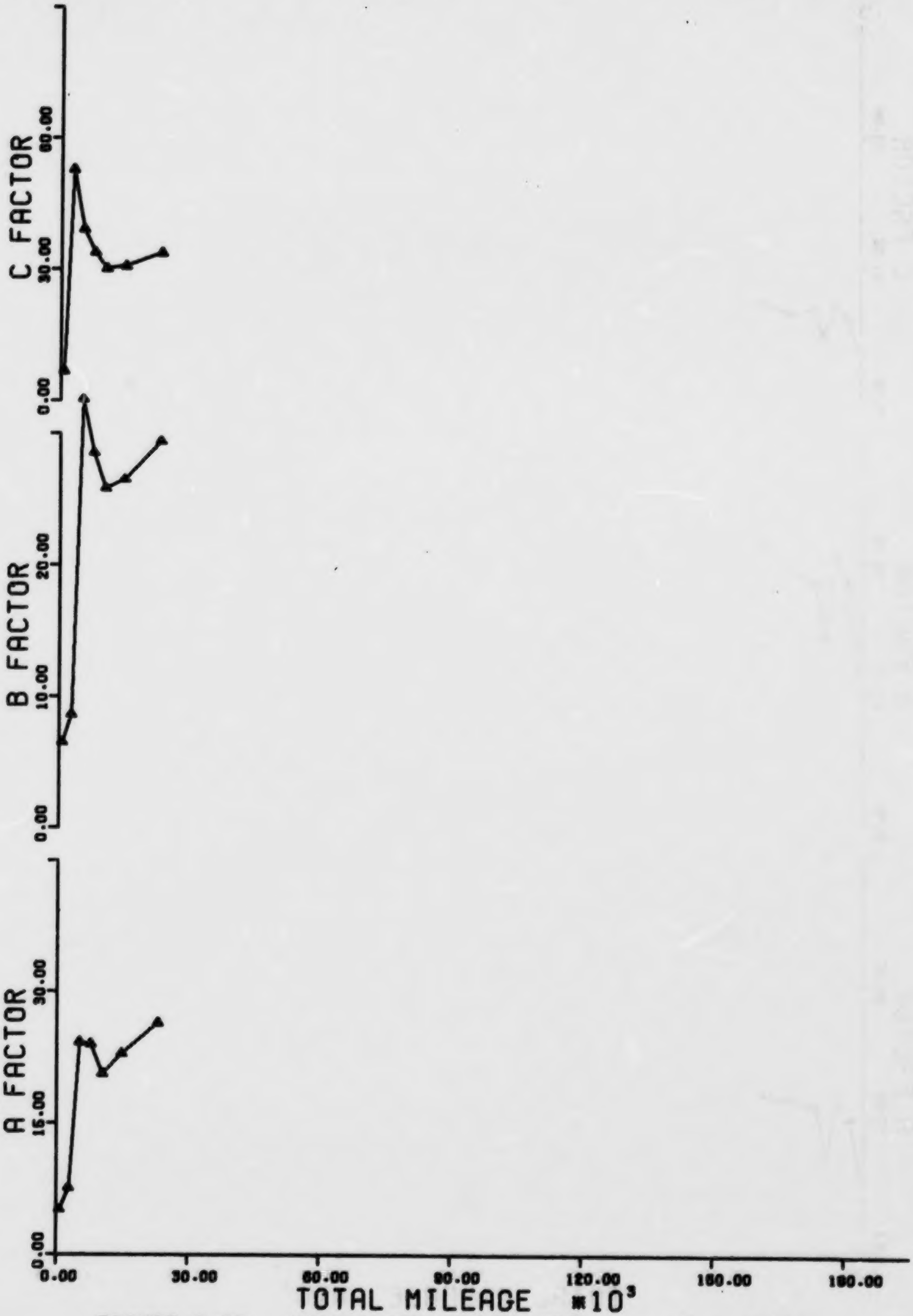

FIGURE D-68. UNIT 137 GM DH-478

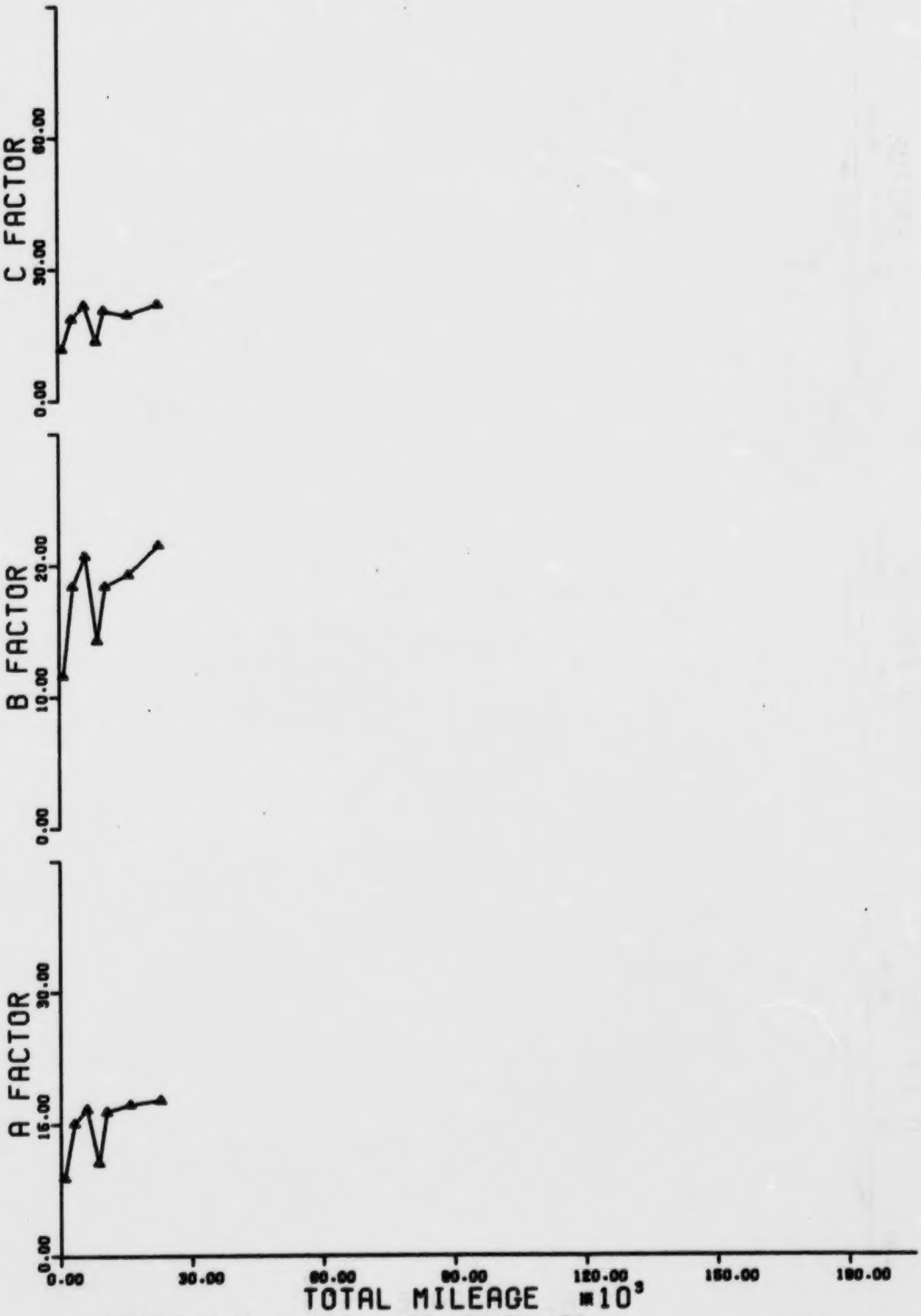

FIGURE D-69. UNIT 190 GM DH-478

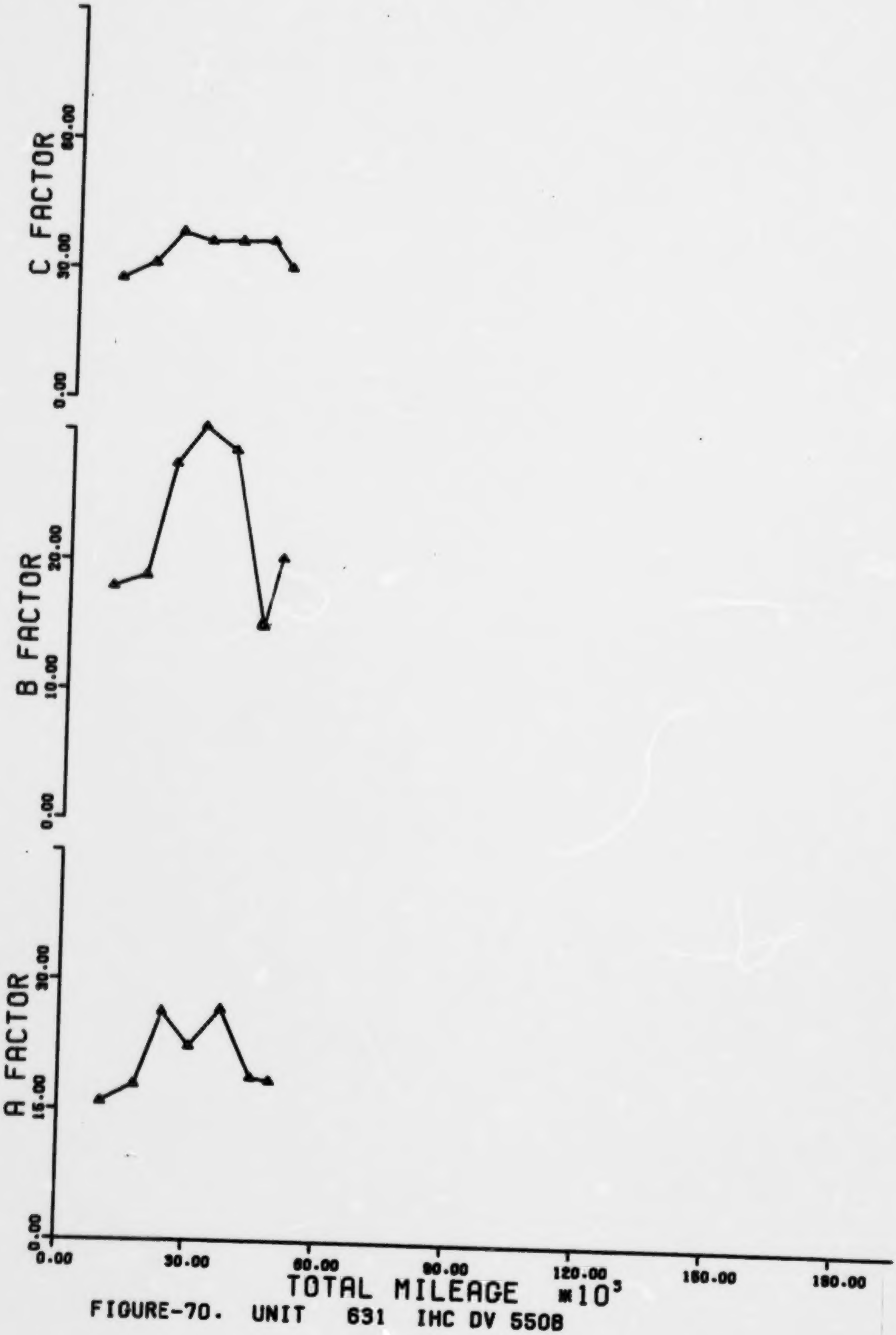

FIGURE-70. UNIT 631 IHC DV 550B

APPENDIX E

STATISTICAL ANALYSIS OF TWO-YEAR DIESEL SURVEILLANCE SMOKE DATA

TABLE E-1. STATISTICAL ANALYSIS OF FIRST-ROUND "a" AND "b" FACTORS FOR ALL FLEET ENGINES

"a" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
0 to 3.99	6	8.6	8.6
4 to 7.99	24	34.3	42.9
8 to 11.99	14	20.0	62.9
12 to 15.99	10	14.3	77.2
16 to 19.99	10	14.3	91.5
20 to 23.99	1	1.4	92.9
24 to 27.99	4	5.7	98.6
28 to 31.99	1	1.4	100.0

Range: 1.5 to 28.7
Total Range: 27.2
Mean: 10.9
Standard Deviation: 6.5
Coefficient of Variation: 0.60
First Quartile: 6.0
Second Quartile: 8.7
Third Quartile: 15.6

"b" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
1 to 2.99	9	12.8	12.8
3 to 4.99	14	20.0	32.8
5 to 6.99	12	17.2	50.0
7 to 8.99	10	14.3	64.3
9 to 10.99	9	12.8	77.1
11 to 12.99	5	7.1	84.2
13 to 14.99	3	4.3	88.5
15 to 16.99	4	5.7	94.2
17 to 18.99	3	4.3	98.6
19 to 20.99	0	0	98.6
21 to 22.99	1	1.4	100.0

Range: 1.0 to 22.4
Total Range: 21.4
Mean: 7.9
Standard Deviation: 4.8
Coefficient of Variation: 0.61
First Quartile: 4.1
Second Quartile: 6.9
Third Quartile: 10.9

TABLE E-2. STATISTICAL ANALYSIS OF SECOND-ROUND "a" AND "b" FACTORS FOR ALL FLEET ENGINES

"a" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
0 to 3.99	8	11.4	11.4
4 to 7.99	17	24.3	35.7
8 to 11.99	8	11.4	47.1
12 to 15.99	14	20.0	67.1
16 to 19.99	10	14.3	81.4
20 to 23.99	5	7.2	88.6
24 to 27.99	2	2.9	91.5
28 to 31.99	3	4.3	95.8
32 to 35.99	1	1.4	97.2
36 to 39.99	1	1.4	98.6
40 to 43.99	1	1.4	100.0

Range: 1.7 to 42.2
Total Range: 40.5
Mean: 13.6
Standard Deviation: 8.8
Coefficient of Variation: 0.64
First Quartile: 6.6
Second Quartile: 12.7
Third Quartile: 18.0

"b" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
1 to 2.99	10	14.3	14.3
3 to 4.99	5	7.2	21.5
5 to 6.99	4	5.8	27.3
7 to 8.99	12	17.2	44.5
9 to 10.99	8	11.4	55.9
11 to 12.99	10	14.3	70.2
13 to 14.99	8	11.4	81.6
15 to 16.99	1	1.4	83.0
17 to 18.99	8	11.4	94.4
19 to 20.99	1	1.4	95.8
21 to 22.99	1	1.4	97.2
23 to 24.99	1	1.4	98.6
25 to 26.99	1	1.4	100.0

Range: 1.0 to 25.0
Total Range: 24.0
Mean: 10.1
Standard Deviation: 5.8
Coefficient of Variation: 0.57
First Quartile: 6.0
Second Quartile: 10.1
Third Quartile: 13.6

TABLE E-3. STATISTICAL ANALYSIS OF THIRD-ROUND "a" AND "b" FACTORS FOR ALL FLEET ENGINES

"a" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
0 to 3.99	3	4.3	4.3
4 to 7.99	13	18.9	23.2
8 to 11.99	12	17.4	40.6
12 to 15.99	10	14.5	55.1
16 to 19.99	11	15.9	71.0
20 to 23.99	7	10.1	81.1
24 to 27.99	5	7.2	88.4
28 to 31.99	4	5.8	94.2
32 to 35.99	1	1.4	95.6
36 to 39.99	1	1.4	97.1
40 to 43.99	1	1.4	98.6
44 to 47.99	1	1.4	100.0

Range: 1.5 to 44.0
Total Range: 42.5
Mean: 16.0
Standard Deviation: 9.4
Coefficient of Variation: 0.59
First Quartile: 8.2
Second Quartile: 14.7
Third Quartile: 20.6

"b" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
0 to 1.99	2	2.9	2.9
2 to 3.99	5	7.2	10.1
4 to 5.99	7	10.1	20.3
6 to 7.99	12	17.4	37.7
8 to 9.99	5	7.2	44.9
10 to 11.99	3	4.3	49.2
12 to 13.99	7	10.1	59.4
14 to 15.99	6	8.7	68.1
16 to 17.99	6	8.7	76.8
18 to 19.99	6	8.7	85.5
20 to 21.99	2	2.9	88.4
22 to 23.99	2	2.9	91.3
24 to 25.99	2	2.9	94.2
26 to 27.99	2	2.9	97.1
28 to 29.99	1	1.4	98.6
30 to 31.99	0	0	98.6
32 to 33.99	1	1.4	100.0

Range: 0.5 to 32.6
Total Range: 32.1
Mean: 12.5
Standard Deviation: 7.4
Coefficient of Variation: 0.59
First Quartile: 6.8
Second Quartile: 12.5
Third Quartile: 17.5

TABLE E-4. STATISTICAL ANALYSIS OF FOURTH-ROUND "a" AND "b" FACTORS FOR ALL FLEET ENGINES

"a" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
0 to 3.99	0	0	0
4 to 7.99	11	16.2	16.2
8 to 11.99	13	19.1	35.3
12 to 15.99	14	20.6	55.9
16 to 19.99	10	14.7	70.6
20 to 23.99	8	11.8	82.4
24 to 27.99	5	7.4	89.8
28 to 31.99	5	7.4	97.2
32 to 35.99	0	0	97.2
36 to 39.99	1	1.4	98.6
40 to 43.99	0	0	98.6
44 to 47.99	1	1.4	100.0

Range: 4.8 to 44.9
Total Range: 40.1
Mean: 16.2
Standard Deviation: 8.2
Coefficient of Variation: 0.51
First Quartile: 9.8
Second Quartile: 14.4
Third Quartile: 22.3

"b" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
0 to 1.99	0	0	0
2 to 3.99	7	10.3	10.3
4 to 5.99	8	11.8	22.1
6 to 7.99	10	14.7	36.8
8 to 9.99	2	2.9	39.7
10 to 11.99	6	8.8	48.5
12 to 13.99	10	14.7	63.2
14 to 15.99	2	2.9	66.1
16 to 17.99	3	4.4	70.5
18 to 19.99	8	11.8	82.3
20 to 21.99	3	4.4	86.7
22 to 23.99	4	5.9	92.6
24 to 25.99	0	0	92.6
26 to 27.99	0	0	92.6
28 to 29.99	1	1.5	94.1
30 to 31.99	3	4.4	98.5
32 to 33.99	1	1.5	100.0

Range: 2.0 to 33.4
Total Range: 31.4
Mean: 13.0
Standard Deviation: 7.9
Coefficient of Variation: 0.61
First Quartile: 6.3
Second Quartile: 12.0
Third Quartile: 19.2

TABLE E-5. STATISTICAL ANALYSIS OF FIFTH-ROUND "a" AND "b" FACTORS FOR ALL FLEET ENGINES

"a" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
0 to 3.99	6	15.385	0
4 to 7.99	2	5.128	15.385
8 to 11.99	3	7.692	20.513
12 to 15.99	3	7.692	28.205
16 to 19.99	4	10.256	35.897
20 to 23.99	6	15.385	46.154
24 to 27.99	8	20.513	61.538
28 to 31.99	3	7.692	82.051
32 to 35.99	1	2.564	89.744
36 to 39.99	1	2.564	92.308
40 to 43.99	1	2.564	94.876
44 to 47.99	0	0	97.436
48 to 51.99	0	0	97.436
52 to 55.99	1	2.564	97.436
56 to 59.99	0	0	100.

Range:	2.1 to 55.5	Coefficient of variation:	59.347
Total Range:	53.4	First Quartile:	11.
Mean:	19.8641	Second Quartile:	20.6
Standard Deviation	11.7888	Third Quartile:	27.3

"b" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
0 to 1.99	0	0	0
2 to 3.99	4	10.256	10.256
4 to 5.99	4	10.256	20.513
6 to 7.99	0	0	20.513
8 to 9.99	2	5.128	25.641
10 to 11.99	4	10.256	35.897
12 to 13.99	6	15.385	51.282
14 to 15.99	3	7.692	58.974
16 to 17.99	0	0	58.974
18 to 19.99	5	12.821	71.795
20 to 21.99	1	2.564	74.359
22 to 23.99	3	7.692	82.051
24 to 25.99	4	10.256	92.308
26 to 27.99	0	0	92.308
28 to 29.99	2	5.128	97.436
30 to 31.99	0	0	97.436
32 to 33.99	0	0	97.436
34 to 35.99	0	0	97.436
36 to 37.99	0	0	97.436
38 to 39.99	1	2.564	100.
40 to 41.99	0	0	100.

Range:	2.1 to 38.5	Coefficient of Variation:	55.578
Total Range:	36.4	First Quartile:	9.9
Mean:	15.3256	Second Quartile:	13.9
Standard Deviation:	8.51767	Third Quartile:	22.5

TABLE E-6. STATISTICAL ANALYSIS OF SIXTH-ROUND "a" AND "b" FACTORS FOR ALL FLEET ENGINES

"a" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
4 to 7.99	0	0	0
8 to 11.99	1	4	4
12 to 15.99	4	16	20
16 to 19.99	4	16	36
20 to 23.99	5	20	56
24 to 27.99	3	12	68
28 to 31.99	4	16	84
32 to 35.99	0	0	84
36 to 39.99	1	4	88
40 to 43.99	1	4	92
44 to 47.99	2	8	100
48 to 51.99	0	0	100

Range:	8 to 47.9	Coefficient of variation:	40.565
Total Range:	39.9	First Quartile:	17.3
Mean:	24.38	Second Quartile:	22.9
Standard Deviation:	9.88979	Third Quartile:	28.4

"b" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
2 to 3.99	0	0	0
4 to 5.99	1	4	4
6 to 7.99	2	8	12
8 to 9.99	1	4	16
10 to 11.99	1	4	20
12 to 13.99	3	12	32
14 to 15.99	3	12	44
16 to 17.99	2	8	52
18 to 19.99	3	12	64
20 to 21.99	1	4	68
22 to 23.99	2	8	76
24 to 25.99	3	12	88
26 to 27.99	1	4	92
28 to 29.99	0	0	92
30 to 31.99	1	4	96
32 to 33.99	0	0	96
34 to 35.99	1	4	100
36 to 37.99	0	0	100

Range:	5.3 to 35.9	Coefficient of Variation:	41.744
Total Range:	30.6	First Quartile:	12.25
Mean:	17.848	Second Quartile:	17.2
Standard Deviation:	7.45043	Third Quartile:	23.2

TABLE E-7. STATISTICAL ANALYSIS OF SEVENTH-ROUND "a" AND "b" FACTORS FOR ALL FLEET ENGINES

"a" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
4 to 7.99	0	0	0
8 to 11.99	1	4.167	4.167
12 to 15.99	2	8.333	12.5
16 to 19.99	6	25.	37.5
20 to 23.99	5	20.833	58.333
24 to 27.99	3	12.5	70.833
28 to 31.99	1	4.167	75.
32 to 35.99	1	4.167	79.167
36 to 39.99	0	0	79.167
40 to 43.99	1	4.167	83.333
44 to 47.99	1	4.167	87.5
48 to 51.99	1	4.167	91.667
52 to 55.99	1	4.167	95.833
56 to 59.99	0	0	95.833
60 to 63.99	1	4.167	100.
64 to 69.99	0	0	100.

Range:	11 to 62.3	Coefficient of variation:	49.236
Total Range:	51.3	First Quartile:	18.65
Mean:	27.4417	Second Quartile:	21.15
Standard Deviation:	13.511	Third Quartile:	32.4

"b" Factors

Percent Opacity Interval	Frequency	Frequency Percentage	Cumulative Percentage
4 to 5.99	0	0	0
6 to 7.99	1	4.167	0
8 to 9.99	1	4.167	4.167
10 to 11.99	0	0	8.333
12 to 13.99	3	12.5	8.333
14 to 15.99	1	4.167	20.833
16 to 17.99	3	12.5	25.
18 to 19.99	4	16.667	37.5
20 to 21.99	5	20.833	54.167
22 to 23.99	2	8.333	75.
24 to 25.99	2	8.333	83.333
26 to 27.99	0	0	91.667
28 to 29.99	1	4.167	91.667
30 to 31.99	1	4.167	95.833
32 to 33.99	0	0	100.

Range:	7 to 31.3	Coefficient of Variation:	30.257
Total Range:	24.3	First Quartile:	14.9
Mean:	18.8917	Second Quartile:	19.55
Standard Deviation:	5.71613	Third Quartile:	22.325

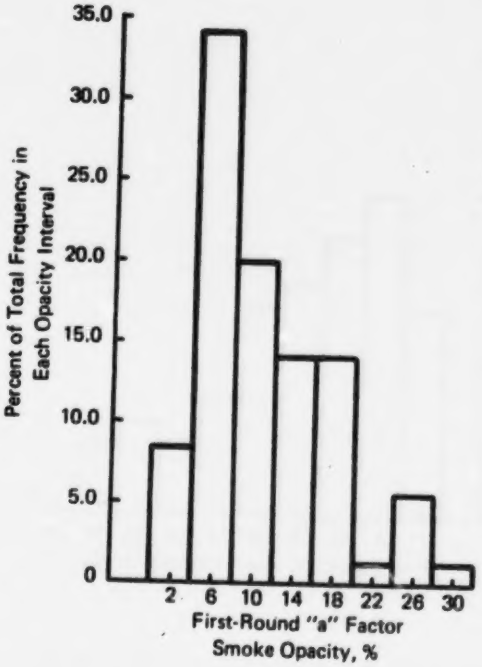

FIGURE E-1. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT FIRST-ROUND TEST

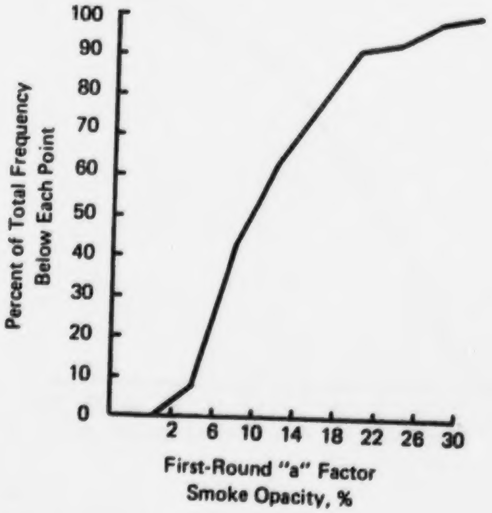

FIGURE E-2. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT FIRST-ROUND TEST

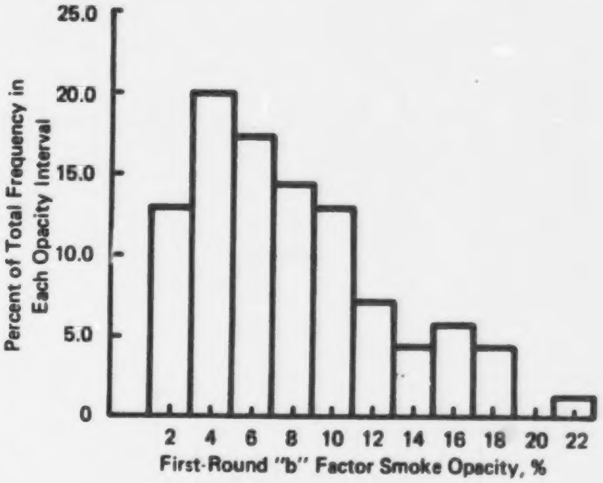

FIGURE E-3. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT FIRST-ROUND TEST

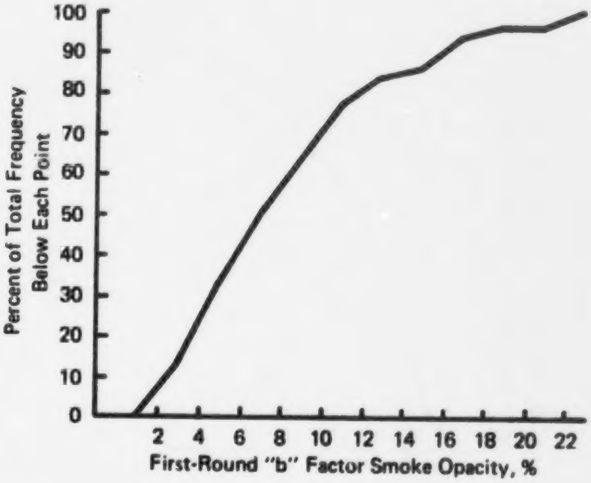

FIGURE E-4. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT FIRST-ROUND TEST

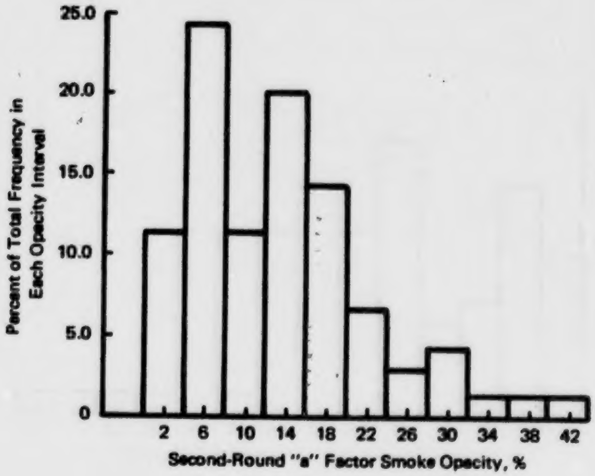

FIGURE E-5. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT SECOND-ROUND TEST

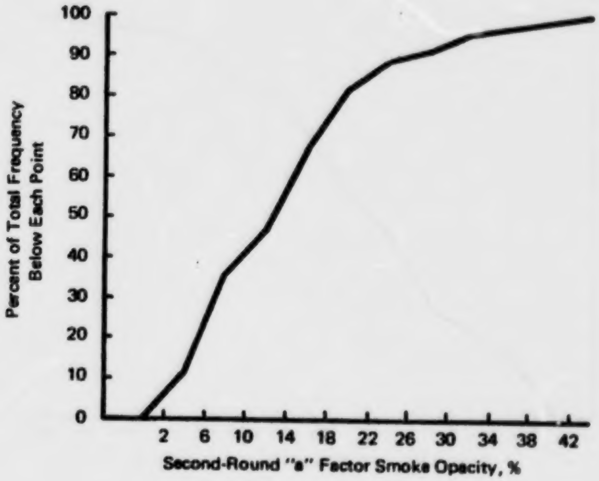

FIGURE E-6. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT SECOND-ROUND TEST

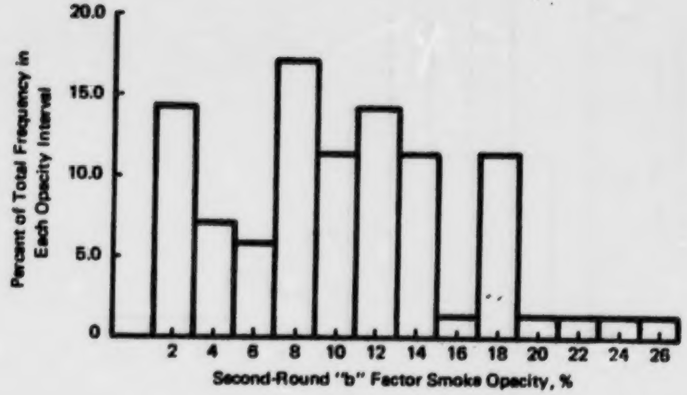

FIGURE E-7. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT SECOND-ROUND TEST

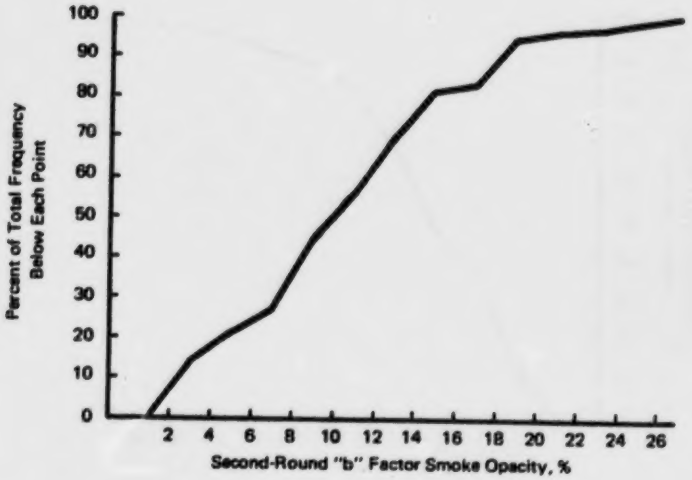

FIGURE E-8. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT SECOND-ROUND TEST

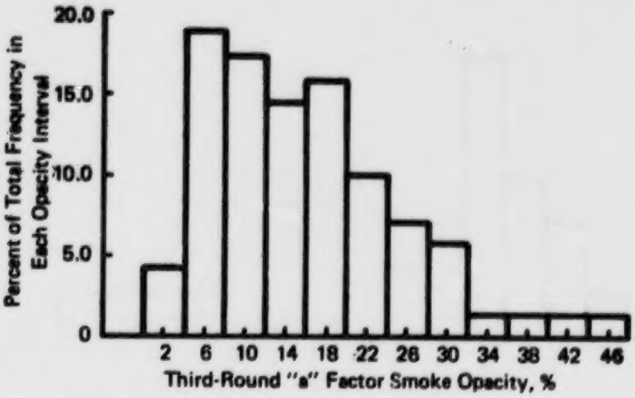

FIGURE E-9. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT THIRD-ROUND TEST

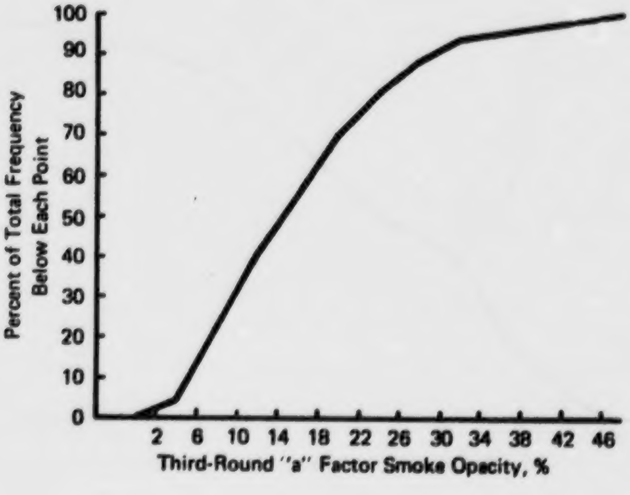

FIGURE E-10. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT THIRD-ROUND TEST

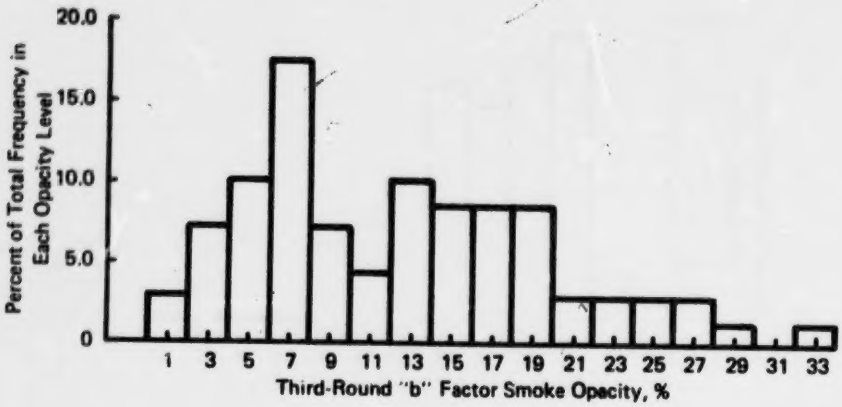

FIGURE E-11. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT THIRD-ROUND TEST

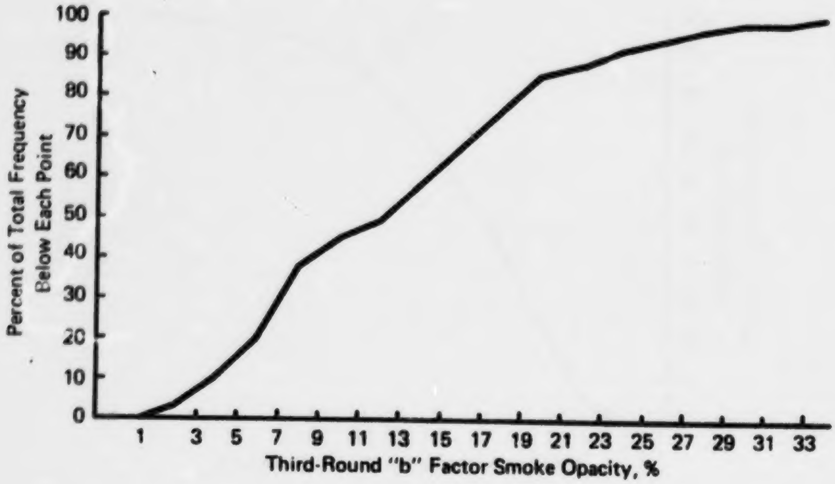

FIGURE E-12. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT THIRD-ROUND TEST

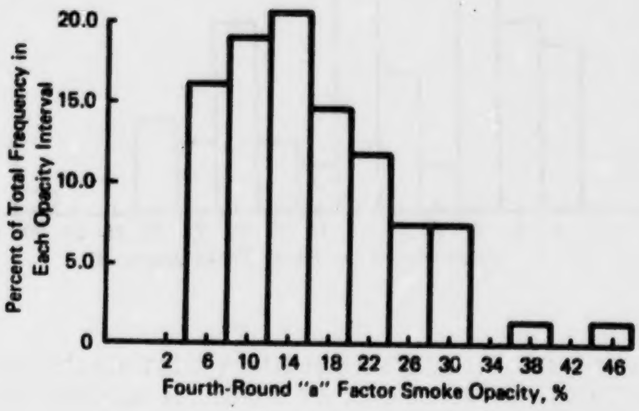

FIGURE E-13. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT FOURTH-ROUND TEST

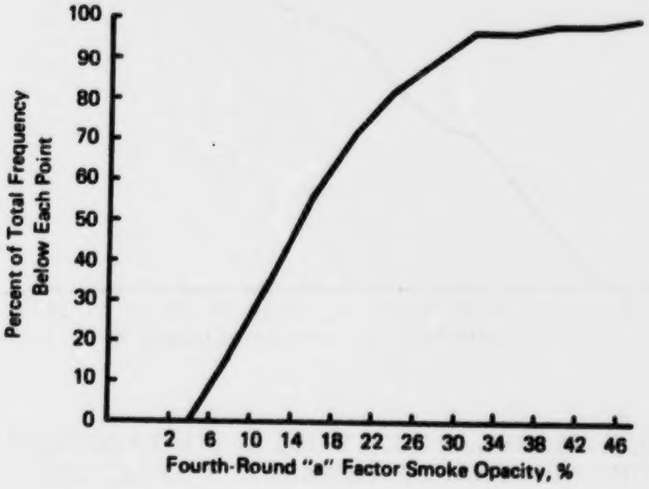

FIGURE E-14. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT FOURTH-ROUND TEST

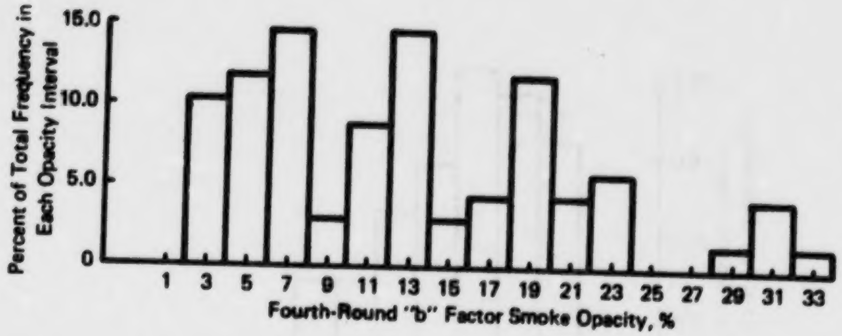

FIGURE E-15. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT FOURTH-ROUND TEST

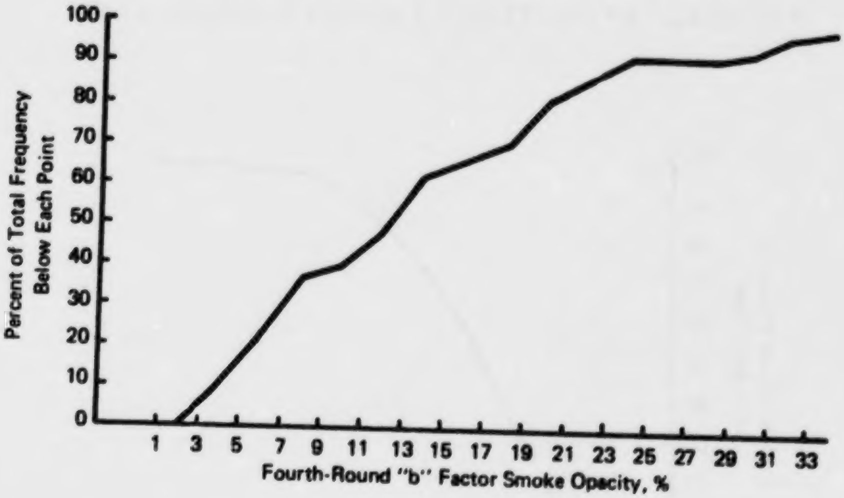

FIGURE E-16. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT FOURTH-ROUND TEST

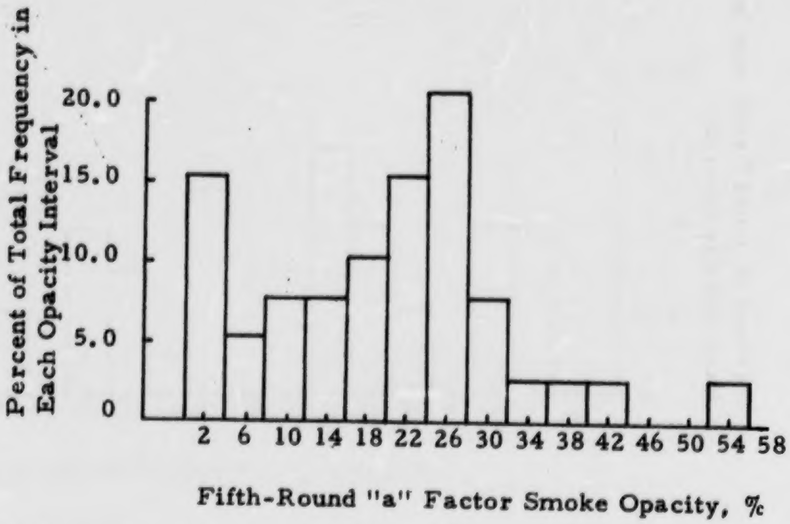

FIGURE E-17. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT FIFTH-ROUND TEST

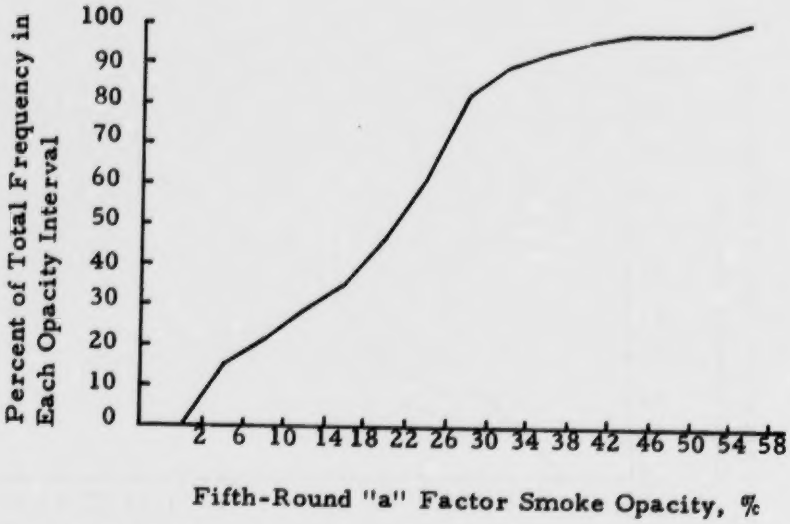

FIGURE E-18. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT FIFTH-ROUND TEST

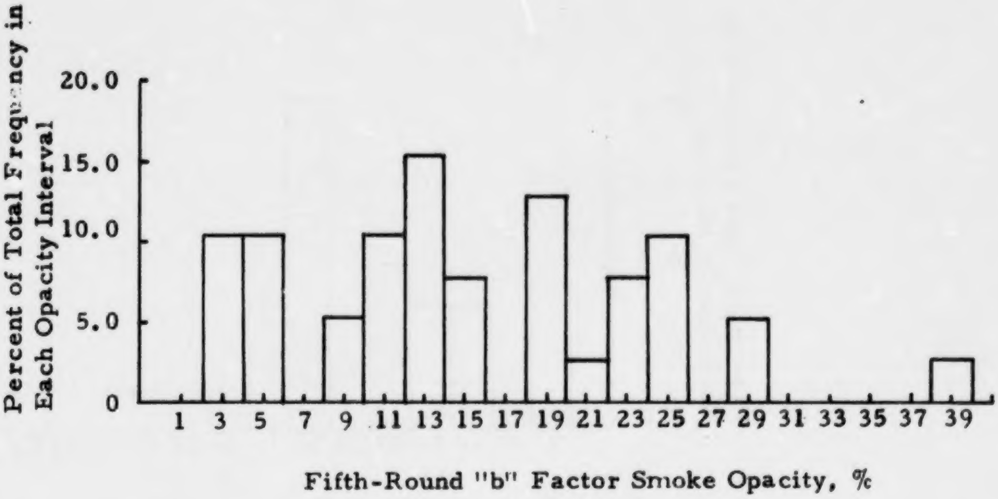

FIGURE E-19. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT FIFTH-ROUND TEST

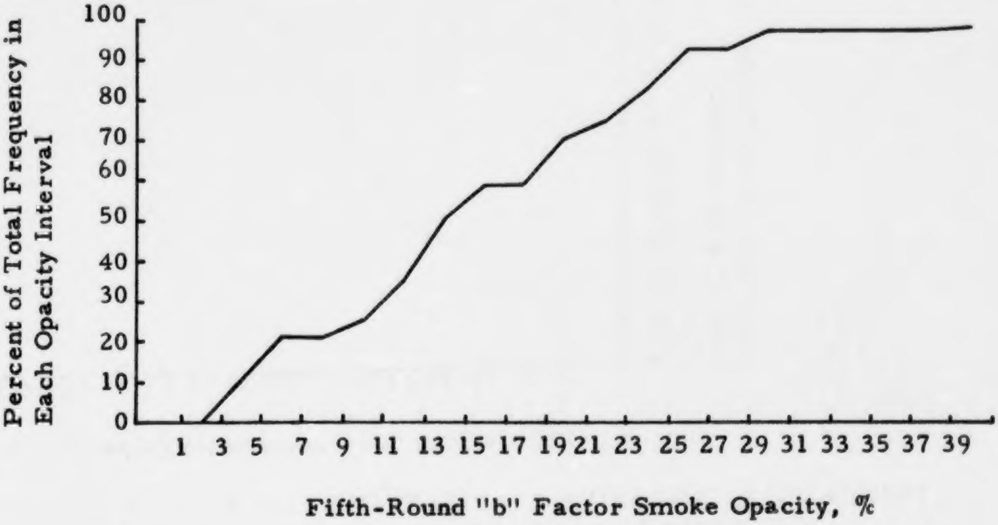

FIGURE E-20. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT FIFTH-ROUND TEST

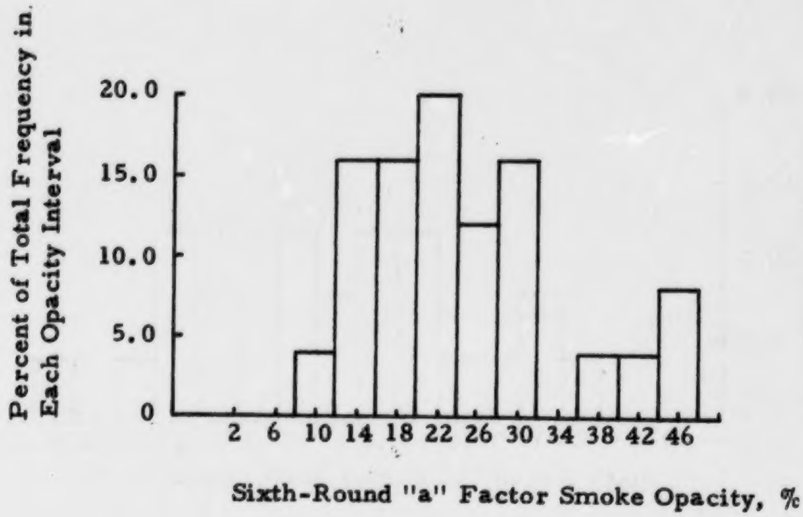

FIGURE E-21. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT SIXTH-ROUND TEST

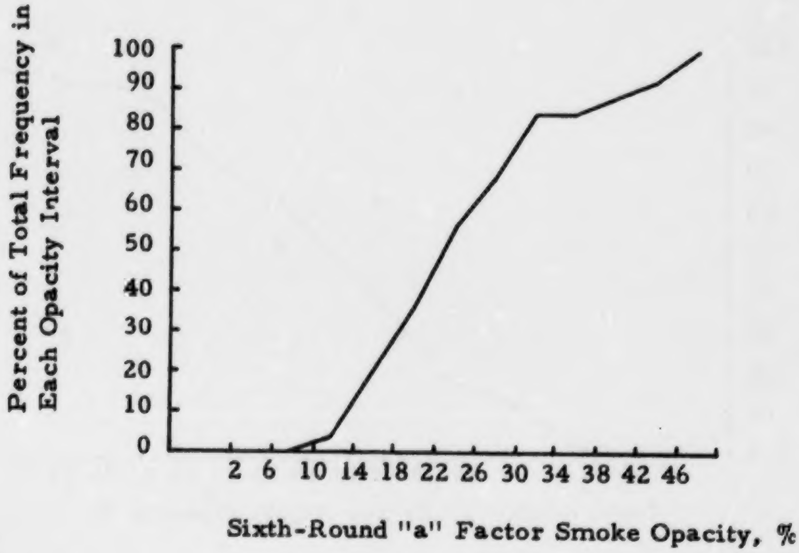

FIGURE E-22. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT SIXTH-ROUND TEST

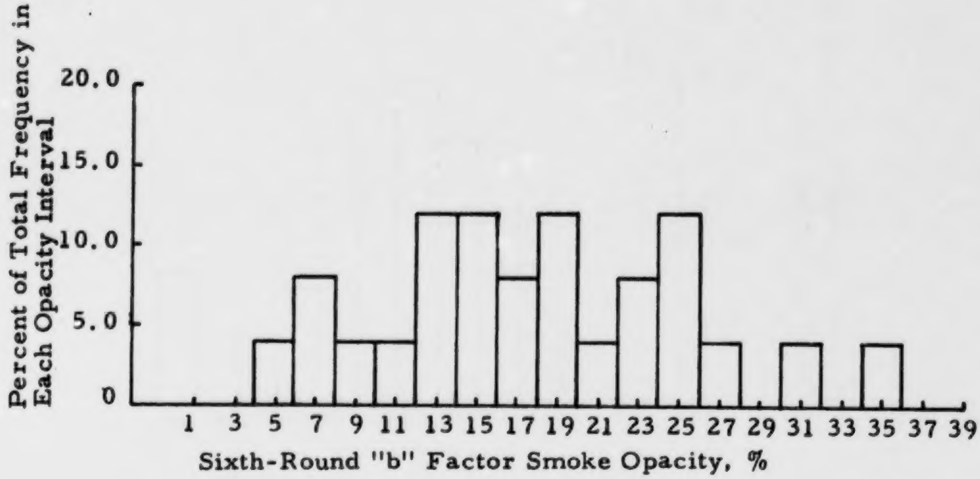

FIGURE E-23. RELATIVE FREQUENCY DISTRIBUTION OF FEFERAL "b" FACTORS AT SIXTH-ROUND TEST

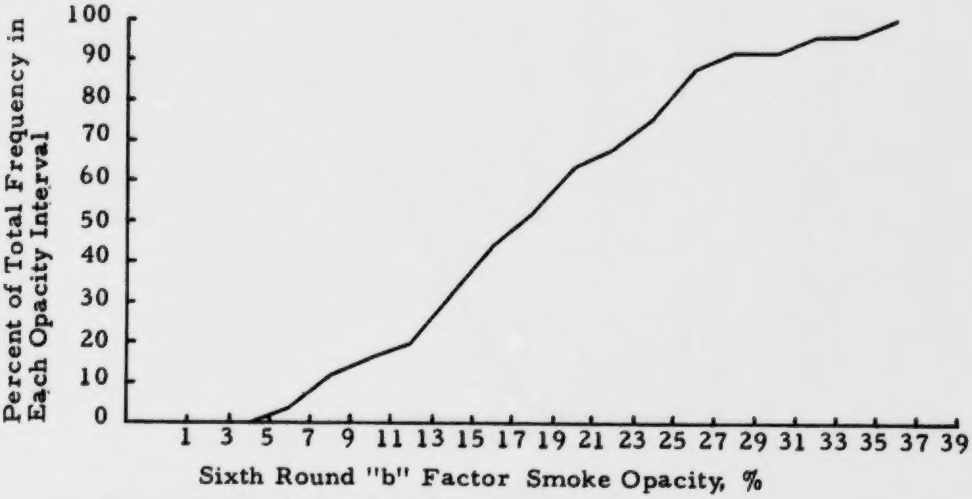

FIGURE E-24. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT SIXTH-ROUND TEST

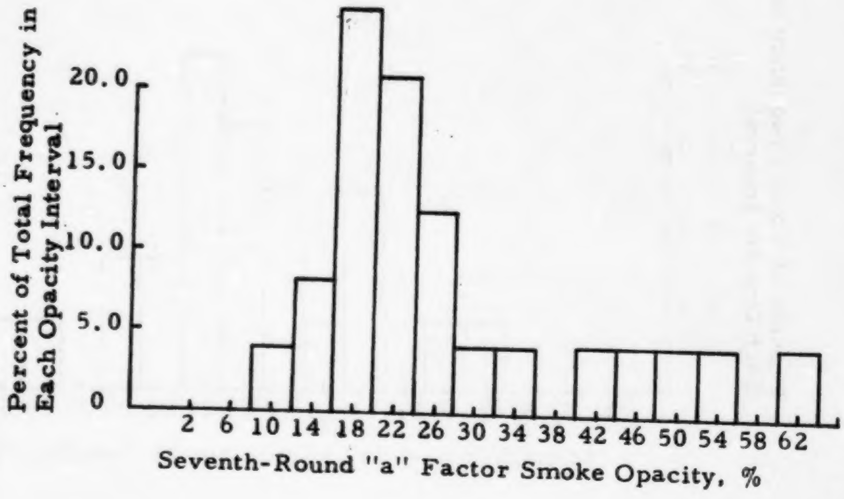

FIGURE E-25. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT SEVENTH-ROUND TEST

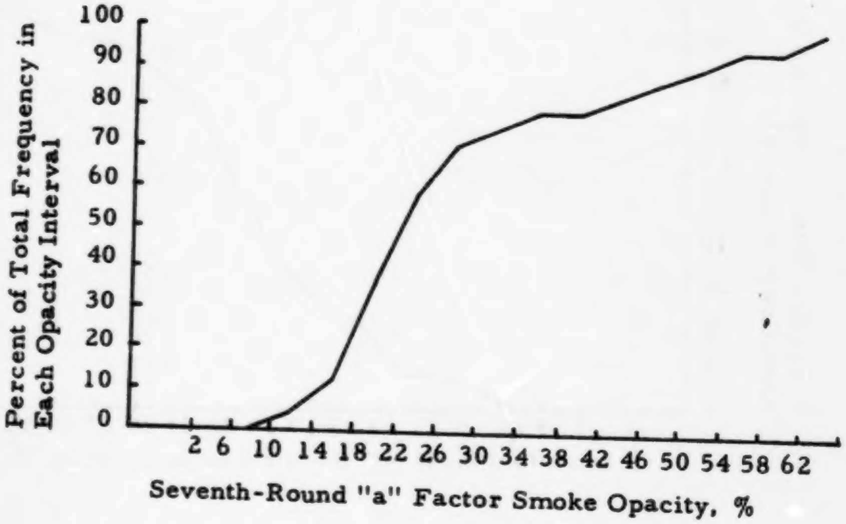

FIGURE E-26, RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "a" FACTORS AT SEVENTH-ROUND TEST

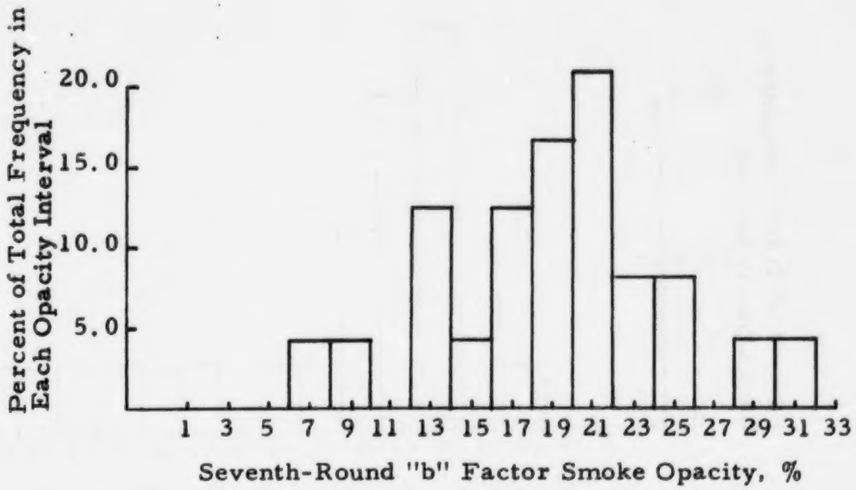

FIGURE E-27. RELATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT SEVENTH-ROUND TEST

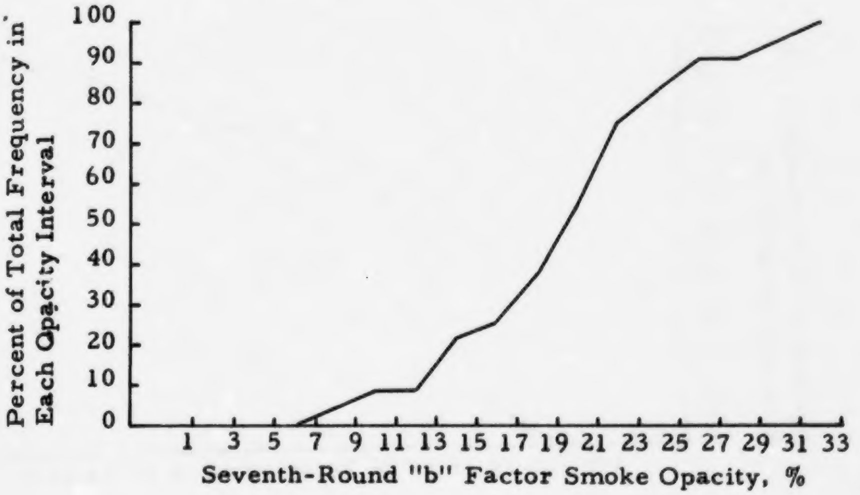

FIGURE E-28. RELATIVE CUMULATIVE FREQUENCY DISTRIBUTION OF FEDERAL "b" FACTORS AT SEVENTH-ROUND TEST

APPENDIX F

TABULAR GASEOUS EMISSIONS DATA FOR CHASSIS VERSION OF 13 MODE EMA-ARB DIESEL TEST PROCEDURE

TABLE F-1 . DETROIT DIESEL 6V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 815/GMC
Source: S. A. Transit
Odom, Miles: 66,203
Date Tested: 11-30-70

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.23	-	29.23
Dry Bulb, °F	83	-	83
Wet Bulb, °F	72	-	72

RUN 1

MODE	C_1H_y, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	186	76	314	Idle	—	12.68	.05	12.73	2.09	1.70	7.55	—
2	209	76	186	1000	—	20.32	.10	20.42	4.51	3.27	8.57	—
3	243	63	512	"	22	20.32	.20	20.52	5.27	2.72	23.70	1.76
4	267	76	885	"	51	20.22	.35	20.57	5.80	3.29	41.07	4.08
5	283	425	1247	"	76	20.22	.50	20.72	6.19	18.53	58.29	6.08
6	452	5200	651	"	102	20.12	.70	20.82	9.94	227.79	30.58	8.16
7	162	63	326	Idle	—	12.68	.05	12.73	1.82	1.41	7.84	—
8	417	1500	1147	1600	148	32.60	.97	33.57	14.78	105.95	86.87	11.84
9	255	114	1179	"	113	32.60	.73	33.33	8.98	7.99	88.15	9.04
10	232	37	899	"	78	32.69	.55	33.24	8.14	2.59	67.42	6.24
11	220	37	524	"	45	32.88	.38	33.26	7.73	2.59	39.32	3.60
12	209	37	228	"	—	33.08	.20	33.28	7.35	2.59	17.12	—
13	186	63	326	Idle	—	12.64	.05	12.69	2.09	1.41	7.82	—
								TOTALS	84.69	381.83	484.80	50.80

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1					—							—
2					—							—
3												
4												
5												
6												
7					—	No Data Taken						—
8												
9												
10												
11												
12					—							—
13					—							—
								TOTALS				

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.67	—
BSCO, g/bhp hr	7.52	—
BSNO, g/bhp hr	9.54	—

TABLE F-2. DETROIT DIESEL 6V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 816/GMC
Source: S. A. Transit
Odom, Miles: 54, 560
Date Tested: 12-1-70

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.20	29.20	29.20
Dry Bulb, °F	81	81	81
Wet Bulb, °F	69	69	69

RUN 1

MODE	C,Hx, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	116	101	260	Idle	—	12.73	.07	12.80	1.31	2.28	6.29	—
2	140	126	156	1000	—	20.32	.10	20.42	3.02	5.41	7.19	—
3	162	101	452	"	26	20.24	.22	20.46	3.50	4.35	20.86	2.08
4	162	114	758	"	54	20.15	.37	20.52	3.51	4.92	35.09	4.32
5	209	572	1066	"	78	20.15	.52	20.67	4.56	23.14	49.71	6.24
6	348	5100	638	"	105	20.05	.73	20.78	7.64	222.38	29.91	8.40
7	128	88	282	Idle	—	12.64	.07	12.71	1.44	1.97	6.77	—
8	209	1800	1066	1600	153	32.01	1.00	33.01	7.29	125.62	79.39	12.24
9	128	229	1051	"	118	32.01	.77	32.78	4.43	15.79	77.72	9.44
10	116	76	744	"	85	32.21	.58	32.79	4.02	5.24	55.04	6.80
11	116	63	416	"	45	32.40	.38	32.78	4.02	4.35	30.76	3.60
12	128	76	176	"	—	32.60	.20	32.80	4.48	5.24	13.02	—
13	128	88	282	Idle	—	12.45	.07	12.52	1.42	1.94	6.67	—
								TOTALS	50.59	422.63	418.42	53.12

RUN 2

MODE	C,Hx, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	139	101	271	Idle	—	12.54	.07	12.61	1.55	2.24	6.46	—
2	162	114	146	1000	—	20.09	.10	20.19	3.45	4.84	6.65	—
3	162	101	440	"	26	20.09	.22	20.31	3.47	4.72	20.16	2.08
4	175	101	758	"	54	19.99	.37	20.36	3.76	4.73	34.82	4.32
5	221	572	1082	"	81	19.85	.53	20.38	4.76	24.53	49.75	6.48
6	348	5200	638	"	103	19.68	.72	20.40	7.50	223.19	29.36	8.24
7	139	76	282	Idle	—	12.45	.07	12.52	1.54	1.68	6.67	—
8	221	1900	1082	1600	151	31.90	.98	32.88	7.67	131.44	80.26	12.08
9	139	255	1066	"	121	31.78	.78	32.56	4.78	17.47	78.30	9.68
10	128	50	771	"	88	31.86	.60	32.46	4.39	3.41	56.46	7.04
11	116	50	416	"	45	32.05	.38	32.43	3.97	3.41	30.44	3.60
12	139	63	186	"	—	32.24	.22	32.46	4.76	4.30	13.62	—
13	128	76	282	Idle	—	12.32	.07	12.39	1.40	1.66	6.60	—
								TOTALS	53.00	426.82	419.55	53.52

g/hr C_nH_{2n} = 0.0132(ppm C,Hx)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.95	0.99
BSCO, g/bhp hr	7.96	7.97
BSNO, g/bhp hr	7.86	7.84

TABLE F-3. DETROIT DIESEL 6V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 817/GMC
Source: S. A. Transit
Odom, Miles: 66,548
Date Tested: 12-2-70

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.17	29.17	29.17
Dry Bulb, °F	83	83	85
Wet Bulb, °F	70	70	71

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	209	126	260	Idle	———	12.68	.07	12.75	2.36	2.83	6.26	———
2	232	152	145	1000	———	20.32	.10	20.42	5.00	6.53	5.59	———
3	302	101	464	"	29	20.32	.23	20.55	6.55	4.77	21.51	2.32
4	325	114	730	"	57	20.22	.38	20.60	7.07	4.94	33.93	4.56
5	360	519	1004	"	81	20.22	.53	20.75	7.89	22.66	47.00	6.48
6	487	4900	664	"	102	20.05	.70	20.75	10.67	213.92	31.08	8.16
7	175	101	282	Idle	———	12.64	.07	12.71	1.97	2.26	6.77	———
8	290	1700	1066	1600	148	32.49	.97	33.46	10.25	119.68	80.47	11.84
9	268	255	1035	"	118	32.37	.75	33.12	9.37	17.77	77.33	9.44
10	244	76	730	"	78	32.57	.55	33.12	8.53	5.30	54.54	6.24
11	209	50	416	"	39	32.77	.38	33.15	7.32	3.49	21.11	3.12
12	232	76	186	"	———	32.96	.22	33.18	8.13	5.31	13.92	———
13	175	101	282	Idle	———	12.60	.07	12.67	2.34	2.25	6.75	———
								TOTALS	87.45	411.31	416.26	52.16

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	141	114	271	Idle	———	12.68	.07	12.75	1.59	2.56	6.53	———
2	186	139	156	1000	———	20.32	.10	20.42	4.01	5.97	7.19	———
3	255	88	512	"	26	20.24	.25	20.49	5.52	3.79	23.67	2.08
4	278	114	744	"	51	20.15	.37	20.52	6.02	4.92	34.44	4.08
5	325	479	989	"	77	20.07	.53	20.60	7.07	20.76	45.96	6.16
6	418	5000	677	"	102	19.98	.68	20.66	9.12	217.34	31.55	8.16
7	141	88	303	Idle	———	12.60	.07	12.67	1.58	1.96	7.25	———
8	244	1700	1066	1600	157	32.37	.98	33.35	8.59	119.29	80.20	12.56
9	244	359	1066	"	115	32.37	.77	33.14	8.54	25.03	79.70	9.20
10	209	63	744	"	78	32.57	.57	33.14	7.31	4.39	55.62	6.24
11	177	50	440	"	45	32.64	.37	33.01	5.61	3.16	29.79	3.60
12	209	63	186	"	———	32.83	.23	33.06	7.30	4.38	13.87	———
13	141	76	282	Idle	———	12.60	.07	12.67	1.58	1.70	6.75	———
								TOTALS	73.84	415.25	422.52	52.08

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.68	1.42
BSCO, g/bhp hr	7.89	7.97
BSNO, g/bhp hr	7.98	8.11

TABLE F-4. DETROIT DIESEL 6V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 818/GMC
Source: S. A. Transit
Odom, Miles: 71,200
Date Tested: 12-3-70

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.19	29.19	29.20
Dry Bulb, °F	81	81	82
Wet Bulb, °F	70	70	71

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	197	101	326	Idle	——	12.68	.07	12.75	2.22	2.27	7.85	——
2	173	101	197	1000	——	20.13	.08	20.21	3.69	4.29	8.98	——
3	162	88	464	"	26	20.13	.22	20.35	3.48	3.77	21.30	2.08
4	186	114	827	"	51	20.03	.35	20.38	4.01	4.89	38.02	4.08
5	325	320	1179	"	83	19.85	.55	20.40	7.00	13.73	54.26	6.64
6	336	5400	638	"	104	19.57	.72	20.29	7.20	230.53	29.20	8.32
7	173	101	326	Idle	——	12.34	.07	12.41	1.90	2.21	7.64	——
8	271	1900	1179	1600	150	31.72	.98	32.70	9.36	130.72	86.98	12.00
9	186	255	1230	"	115	31.72	.75	32.47	6.38	17.42	95.10	9.20
10	150	86	885	"	78	31.91	.55	32.46	5.14	6.01	64.81	6.24
11	139	76	475	"	45	32.10	.38	32.48	4.77	5.19	34.81	3.60
12	150	76	239	"	——	32.60	.17	32.77	5.19	5.24	17.67	——
13	139	101	337	Idle	——	12.57	.07	12.64	1.55	2.25	8.05	——
								TOTALS	61.88	428.52	469.17	52.16

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	150	88	282	Idle	——	12.57	.06	12.63	1.68	1.96	6.73	——
2	162	88	156	1000	——	20.13	.10	20.23	3.46	3.75	7.12	——
3	150	76	416	"	23	20.13	.20	20.33	3.22	3.25	19.08	1.84
4	162	101	799	"	51	19.85	.35	20.20	3.46	4.29	36.41	4.08
5	278	333	1196	"	81	19.85	.53	20.38	5.98	14.28	54.99	6.48
6	360	5400	638	"	104	19.57	.73	20.30	7.72	230.64	29.22	8.32
7	139	76	303	Idle	——	12.34	.06	12.40	1.52	1.16	7.10	——
8	325	1600	1196	1600	150	31.72	.98	32.70	11.22	110.08	88.23	12.00
9	139	203	1163	"	113	31.72	.73	32.45	4.76	13.86	85.14	9.04
10	128	63	827	"	78	31.91	.55	32.46	4.39	4.30	60.56	6.24
11	116	50	440	"	42	32.10	.37	32.47	3.98	3.42	32.23	3.36
12	139	50	197	"	——	32.29	.18	32.47	4.77	3.42	14.53	——
13	128	76	303	Idle	——	12.34	.05	12.39	1.40	1.66	7.09	——
								TOTALS	57.56	396.07	448.32	51.36

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.19	1.12
BSCO, g/bhp hr	8.22	7.71
BSNO, g/bhp hr	9.00	8.73

TABLE F-5. DETROIT DIESEL 6V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 819/GMC
Source: S. A. Transit
Odom, Miles: 72,542
Date Tested: 12-4-70

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.24	29.24	29.24
Dry Bulb, °F	83	83	84
Wet Bulb, °F	71	71	72

RUN 1

MODE	C,H,, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	186	126	260	Idle	———	12.68	.07	12.75	2.10	2.83	6.26	———
2	186	152	145	1000	———	20.31	.10	20.41	4.01	6.53	6.68	———
3	186	114	393	"	26	20.24	.22	20.46	4.02	4.91	18.14	2.08
4	196	126	717	"	51	20.07	.35	20.42	4.27	5.41	33.02	4.08
5	244	536	1020	"	76	19.85	.50	20.35	5.24	22.95	46.83	6.08
6	348	6300	730	"	104	19.57	.72	20.29	7.46	268.95	33.42	8.32
7	139	126	292	Idle	———	12.41	.07	12.48	1.53	2.77	6.89	———
8	174	2000	1082	1600	151	31.30	.98	32.28	5.93	135.83	78.80	12.08
9	139	203	1004	"	104	31.60	.68	32.28	4.74	13.79	73.12	8.32
10	127	114	690	"	72	32.09	.52	32.61	4.37	7.82	50.76	5.76
11	127	101	416	"	35	32.28	.33	32.61	4.77	6.93	30.60	2.80
12	116	114	186	"	———	32.48	.20	32.68	4.00	7.84	13.71	———
13	127	126	282	Idle	———	12.41	.08	12.49	1.40	2.77	6.65	———
								TOTALS	53.44	489.33	404.69	49.52

RUN 2

MODE	C,H,, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	174	101	282	Idle	———	12.64	.07	12.71	1.96	2.26	6.77	———
2	174	126	156	1000	———	20.32	.10	20.42	3.75	5.41	7.19	———
3	174	88	416	"	26	20.24	.22	20.46	3.76	2.79	19.20	2.08
4	186	101	730	"	51	19.89	.35	20.24	3.98	4.30	33.33	4.08
5	232	472	1035	"	76	19.85	.50	20.35	4.99	18.07	47.52	6.08
6	336	5900	717	"	104	19.61	.72	20.33	7.21	252.37	32.88	8.32
7	139	88	303	Idle	———	12.48	.07	12.55	1.84	1.95	7.18	———
8	162	1900	1098	1600	153	31.30	1.00	32.30	5.53	129.12	80.01	12.24
9	139	203	1004	"	107	31.30	.70	32.00	4.70	13.67	72.48	8.56
10	139	88	690	"	75	31.73	.53	32.26	4.74	5.97	50.22	6.00
11	139	88	393	"	35	31.92	.33	32.25	4.73	5.97	28.59	2.80
12	150	88	186	"	———	32.66	.20	32.86	5.21	6.08	13.79	———
13	139	101	282	Idle	———	12.57	.08	12.65	1.56	2.25	6.74	———
								TOTALS	53.96	451.21	405.90	50.16

g/hr C_nH_{2n} = 0.0132(ppm C,H,)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.08	1.08
BSCO, g/bhp hr	9.88	8.99
BSNO, g/bhp hr	8.18	8.09

TABLE F-6. DETROIT DIESEL 6V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No./Make: 820/GMC
Source: S. A. Transit
Odom, Miles: 65,590
Date Tested: 12-7-70

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.42		29.42
Dry Bulb, °F	74	76	78
Wet Bulb, °F	64	65	66

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	139	114	314	Idle	———	12.73	.07	12.80	1.57	2.57	7.59	———
2	139	114	218	1000	———	20.39	.10	20.49	3.01	4.91	10.08	———
3	139	76	524	"	25	20.32	.22	20.54	3.01	3.28	24.28	2.00
4	139	101	885	"	51	20.22	.35	20.57	3.02	4.37	41.07	4.08
5	174	333	1264	"	78	20.03	.52	20.55	3.78	14.40	58.10	6.24
6	348	7000	758	"	103	19.93	.72	20.65	7.59	304.13	35.31	8.24
7	127	101	337	Idle	———	12.57	.05	12.62	1.42	2.46	8.04	———
8	197	2000	1316	"	151	32.31	.98	33.29	6.93	140.08	98.83	12.08
9	139	126	1230	"	113	32.31	.73	33.04	4.85	8.76	91.68	9.04
10	127	76	841	"	75	32.50	.53	33.03	4.43	5.28	62.67	6.00
11	127	50	475	"	42	32.70	.37	33.07	4.44	3.48	35.44	3.36
12	139	63	228	"	———	32.90	.22	33.12	4.86	4.39	17.04	———
13	127	88	326	Idle	———	12.57	.08	12.65	1.42	1.96	7.79	———
								TOTALS	49.62	500.07	498.42	51.04

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	127	101	326	Idle	———	12.68	.07	12.75	1.43	2.27	7.56	———
2	139	101	207	1000	———	20.32	.08	20.40	2.99	4.33	10.03	———
3	139	76	561	"	25	20.32	.22	20.54	3.01	3.28	24.28	2.00
4	139	88	899	"	51	20.22	.35	20.57	3.02	3.81	41.07	4.08
5	162	294	1298	"	81	20.03	.53	20.56	3.52	12.72	58.63	6.48
6	348	6400	771	"	102	19.93	.70	20.63	7.58	277.80	32.28	8.16
7	127	76	348	Idle	———	12.57	.05	12.62	1.42	1.69	8.04	———
8	186	2000	1335	1600	151	32.31	.98	33.29	6.54	140.08	98.83	12.08
9	139	101	1264	"	113	32.31	.73	33.04	4.85	7.02	91.68	9.04
10	127	50	856	"	75	32.21	.53	32.74	4.39	3.44	62.12	6.00
11	127	50	487	"	45	32.40	.38	32.78	4.40	3.45	35.12	3.60
12	139	50	239	"	———	32.60	.22	32.82	4.82	3.45	16.68	———
13	127	76	337	Idle	———	12.45	.08	12.53	1.41	1.68	7.72	———
								TOTALS	49.38	465.02	494.25	51.44

		RUN 1	RUN 2
g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)	BSHC, g/bhp hr	0.97	0.96
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)	BSCO, g/bhp hr	9.80	9.04
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)	BSNO, g/bhp hr	9.77	9.61

TABLE F-7. DETROIT DIESEL 6V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 821/GMC
Source: S. A. Transit
Odom, Miles: 68,137
Date Tested: 12-8-70

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.23	-	-
Dry Bulb, °F	82	82	84
Wet Bulb, °F	70	70	72

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	151	114	326	Idle	———	12.68	.07	12.75	1.70	2.56	7.85	———
2	151	126	197	1000	———	20.32	.10	20.42	3.26	5.41	9.08	———
3	151	101	464	"	25	20.32	.21	20.53	3.27	4.36	21.49	2.00
4	151	114	813	"	54	20.22	.36	20.58	3.28	4.94	37.75	4.32
5	174	281	1098	"	77	20.15	.50	20.65	3.79	12.21	51.15	6.16
6	325	7000	717	"	102	19.82	.70	20.52	7.04	302.22	33.19	8.16
7	139	114	314	Idle	———	12.64	.06	12.70	1.56	2.55	7.53	———
8	174	1500	1196	1600	152	32.01	1.00	33.01	6.07	104.18	89.07	12.16
9	139	178	1130	"	113	32.01	.73	32.74	4.81	12.22	83.46	9.04
10	139	101	799	"	72	32.21	.51	32.72	4.80	6.95	58.98	5.76
11	139	76	452	"	42	32.40	.36	32.76	4.81	5.24	33.41	3.36
12	162	76	197	"	———	32.60	.18	32.78	5.61	5.24	14.57	———
13	162	101	303	Idle	———	12.57	.06	12.63	1.81	2.25	7.23	———
								TOTALS	52.80	470.37	454.76	50.96

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	151	101	326	Idle	———	12.68	.06	12.74	1.70	2.27	7.85	———
2	151	114	197	1000	———	20.32	.09	20.41	3.25	4.90	9.07	———
3	139	88	512	"	25	20.32	.21	20.53	3.01	3.80	23.71	2.00
4	139	101	813	"	51	20.15	.35	20.50	3.01	4.36	37.60	4.08
5	186	359	1163	"	77	20.03	.50	20.53	4.03	15.51	53.87	6.16
6	302	7400	744	"	103	19.93	.71	20.64	6.58	321.36	34.64	8.24
7	139	101	303	Idle	———	12.57	.05	12.62	1.55	2.25	7.22	———
8	162	1500	1213	1600	151	32.31	.98	33.29	5.70	105.06	91.10	12.08
9	151	203	1179	"	113	32.31	.73	33.04	5.27	14.11	87.88	9.04
10	139	88	827	"	75	32.21	.53	32.74	4.81	6.06	61.08	6.00
11	139	76	463	"	38	32.40	.35	32.75	4.81	5.24	34.21	3.04
12	151	88	197	"	———	32.90	.18	33.08	5.27	6.12	15.02	———
13	151	101	303	Idle	———	12.68	.05	12.73	1.70	2.27	7.29	———
								TOTALS	50.69	493.31	470.54	50.64

g/hr C_nH_{2n} = 0.0132 (ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.04	1.00
BSCO, g/bhp hr	9.23	9.74
BSNO, g/bhp hr	8.92	9.29

TABLE F-8. DETROIT DIESEL 6V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 822/GMC
Source: S. A. Transit
Odom, Miles: 69,155
Date Tested: 12-9-70

Inlet Conditions	Before	Between	After
Bar, in Hg Corr		29.21	
Dry Bulb, °F	88	88	90
Wet Bulb, °F	75	74	76

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	162	126	303	Idle	——	12.57	.07	12.64	1.81	2.81	7.24	——
2	162	152	186	1000	——	20.13	.08	20.21	3.46	6.46	8.48	——
3	151	126	475	"	22	20.13	.20	20.33	3.24	5.39	21.79	1.76
4	162	178	899	"	51	20.03	.35	20.38	3.49	7.63	41.37	4.08
5	232	386	1281	"	77	20.03	.50	20.53	5.03	16.67	59.37	6.16
6	371	7200	690	"	102	19.75	.70	20.45	8.01	309.79	31.83	8.16
7	162	126	282	Idle	——	12.45	.06	12.51	1.79	2.78	6.67	
8	289	2000	1281	1600	151	32.01	.98	32.99	10.07	138.82	95.34	12.08
9	162	178	1264	"	114	32.01	.73	32.74	5.60	12.26	93.36	9.12
10	151	101	899	"	72	32.21	.51	32.72	5.22	6.95	66.36	5.76
11	139	88	487	"	42	32.40	.36	32.76	4.81	6.07	35.99	3.36
12	162	101	218	"	——	32.60	.18	32.78	5.61	6.97	16.12	
13	162	126	303	Idle	——	12.45	.08	12.53	1.80	2.78	7.17	——
								TOTALS	59.94	525.38	491.01	50.48

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	139	126	326	Idle	——	12.57	.06	12.63	1.55	2.80	7.78	——
2	139	126	197	1000	——	20.13	.10	20.23	2.97	5.36	8.99	——
3	139	114	512	"	26	20.13	.21	20.34	2.99	4.88	23.49	2.08
4	151	139	929	"	51	19.85	.35	20.20	3.22	5.91	42.34	4.08
5	232	386	1298	"	77	19.85	.50	20.35	4.99	16.53	59.59	6.16
6	349	7000	717	"	102	19.75	.70	20.45	7.75	301.20	33.08	8.16
7	139	114	337	Idle	——	12.45	.08	12.53	1.54	2.52	7.98	
8	278	2300	1298	1600	151	32.01	.98	32.99	9.68	159.65	96.60	12.08
9	151	152	1264	"	114	32.01	.73	32.74	5.22	10.47	93.36	9.12
10	139	88	885	"	76	32.21	.53	32.54	4.81	6.06	65.77	6.08
11	139	76	536	"	42	32.40	.36	32.76	4.81	5.24	39.61	3.36
12	151	76	279	"	——	32.90	.20	33.10	5.28	5.29	17.85	——
13	151	101	337	Idle	——	12.47	.08	12.55	1.69	2.25	8.05	——
								TOTALS	56.50	528.15	504.09	51.12

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.19	1.11
BSCO, g/bhp hr	10.41	10.73
BSNO, g/bhp hr	9.73	9.86

TABLE F-9. DETROIT DIESEL 6V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 823/GMC
Source: S. A. Transit
Odom, Miles: 69,855
Date Tested: 12-10-70

Inlet Conditions	Before	Between	After
Bar, in Hg Corr		29.30	
Dry Bulb, °F	87	88	89
Wet Bulb, °F	74	74	76

RUN 1

MODE	C,Hx, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	139	139	326	Idle	———	12.68	.05	12.73	1.56	3.12	7.84	———
2	162	165	197	1000	———	20.32	.10	20.42	3.49	7.09	9.08	———
3	139	121	536	"	26	20.32	.21	20.53	3.01	5.44	24.83	2.08
4	151	139	885	"	50	20.22	.34	20.56	3.28	6.01	41.05	4.00
5	197	281	1298	"	76	20.22	.50	20.72	4.31	12.25	60.67	6.08
6	348	7000	744	"	102	19.93	.70	20.63	7.58	303.84	34.63	8.16
7	139	152	348	Idle	———	12.57	.05	12.62	1.55	3.38	8.30	———
8	255	1400	1281	1600	153	32.01	1.00	33.01	8.89	97.23	95.40	12.24
9	162	190	1333	"	113	32.01	.77	32.74	5.60	13.09	98.46	9.04
10	151	126	912	"	75	32.21	.57	32.74	5.22	8.68	67.36	6.00
11	151	114	487	"	38	32.40	.35	32.75	5.22	7.86	35.98	3.04
12	162	139	228	"	———	32.60	.20	32.80	5.61	9.59	16.57	———
13	151	152	337	Idle	———	12.45	.05	12.50	1.67	3.35	7.96	———
								TOTALS	56.99	480.93	508.43	50.64

RUN 2

MODE	C,Hx, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	139	126	326	Idle	———	12.57	.05	12.62	1.55	2.86	7.77	———
2	162	152	197	1000	———	20.13	.10	20.23	3.46	6.47	8.99	———
3	151	101	524	"	26	20.13	.21	20.34	3.24	4.32	24.04	2.08
4	151	114	885	"	50	20.03	.34	20.37	3.25	4.89	40.67	4.00
5	197	255	1281	"	75	19.85	.49	20.34	4.23	10.91	58.78	6.00
6	348	7500	730	"	103	19.75	.70	20.45	7.52	322.70	37.68	8.24
7	139	139	326	Idle	———	12.45	.05	12.50	1.54	3.06	7.70	———
8	232	1300	1298	1600	150	32.01	.98	32.99	8.08	90.23	96.60	12.00
9	139	165	1298	"	113	32.01	.73	32.74	4.81	11.37	95.87	9.04
10	139	101	885	"	74	32.21	.52	32.73	4.80	6.96	65.75	5.92
11	139	101	464	"	38	32.40	.35	32.75	4.81	6.96	34.28	3.04
12	162	126	207	"	———	32.60	.20	32.80	5.61	8.70	15.32	———
13	139	114	303	Idle	———	12.45	.06	12.51	1.54	2.51	7.16	———
								TOTALS	54.44	481.88	496.21	50.32

g/hr C_nH_{2n} = 0.0132 (ppm C,Hx) (EXH. FLOW, lb/min) (Weight Factor)

g/hr CO = 0.0263 (ppm CO) (EXH. FLOW, lb/min) (Weight Factor)

g/hr NO = 0.0782 (ppm NO) (EXH. FLOW, lb/min) (Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.13	1.08
BSCO, g/bhp hr	9.50	9.58
BSNO, g/bhp hr	10.04	9.86

TABLE F-10. DETROIT DIESEL 6V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 824/GMC
Source: S. A. Transit
Odom, Miles: 67,223
Date Tested: 12-11-70

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.32	29.34	29.34
Dry Bulb, °F	70	77	70
Wet Bulb, °F	55	57	58

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	162	114	303	Idle	—	12.80	.06	12.86	1.84	2.58	7.36	—
2	174	126	197	1000	—	20.50	.09	20.59	3.78	5.46	9.15	—
3	151	101	536	"	27	20.50	.22	20.72	3.30	4.40	25.06	2.16
4	162	126	914	"	57	20.22	.38	20.60	3.52	5.46	42.48	4.56
5	232	333	1179	"	81	20.22	.53	20.75	5.08	14.54	55.19	6.48
6	313	7,400	730	"	104	20.12	.71	20.83	6.88	324.31	34.30	8.32
7	139	114	303	Idle	—	12.68	.08	12.76	1.56	2.56	7.30	—
8	209	1,600	1213	1600	150	33.10	.98	33.58	7.41	113.04	91.89	12.00
9	139	203	1179	"	115	33.60	.74	33.34	4.89	14.24	88.68	9.20
10	116	101	870	"	69	33.40	.50	33.90	4.08	7.08	65.76	5.52
11	116	88	487	"	43	33.00	.37	33.37	4.09	6.18	36.66	3.44
12	139	101	218	"	—	33.20	.18	33.38	4.90	7.09	16.42	—
13	139	114	303	Idle	—	12.68	.05	12.73	1.56	2.56	7.29	—
								TOTALS	52.89	509.50	487.14	51.68

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	139	114	326	Idle	—	12.80	.05	12.85	1.58	2.58	7.91	—
2	151	126	197	1000	—	20.50	.10	20.60	3.28	5.46	9.16	—
3	139	101	536	"	29	20.50	.23	20.73	3.04	4.41	25.07	2.32
4	139	126	914	"	57	20.40	.38	20.78	3.05	5.51	42.85	4.56
5	197	333	1270	"	78	20.22	.51	20.73	4.31	14.52	57.52	6.24
6	325	7400	744	"	102	20.12	.70	20.82	7.15	324.16	34.95	8.16
7	139	101	337	Idle	—	12.68	.05	12.73	1.56	2.27	8.11	—
8	197	1600	1247	1600	148	32.60	.96	33.56	6.98	112.98	94.41	11.84
9	162	190	1333	"	115	32.60	.75	33.35	5.71	13.33	100.29	9.20
10	116	76	929	"	75	33.40	.53	33.93	4.08	5.33	69.85	6.00
11	116	76	512	"	38	33.00	.35	33.35	4.09	5.33	38.52	3.04
12	139	101	239	"	—	33.20	.20	33.40	4.90	7.10	18.01	—
13	116	114	337	Idle	—	12.68	.08	12.76	1.31	2.56	8.12	—
								TOTALS	51.04	505.54	514.77	51.36

g/hr C_nH_{2n} = 0.0132 (ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.02	0.99
BSCO, g/bhp hr	9.86	9.84
BSNO, g/bhp hr	9.43	10.02

TABLE F-11. DETROIT DIESEL 8V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 104/GMC
Source: H. E. B.
Odom, Miles: 62,856
Date Tested: 12-19-70

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.17	-	-
Dry Bulb, °F	70	70	70
Wet Bulb, °F	61	61	61

RUN 1 - Left Engine Bank

MODE	C,H$_x$, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	128	101	228	Idle	—	8.45	.03	8.48	0.96	1.51	3.15	—
2	[illegible]	101	197	1600	—	22.10	.07	22.17	1.94	4.71	9.85	—
3	162	63	612	"	33	22.10	.25	22.35	3.82	[illegible]	30.86	2.64
4	[illegible]	63	914	"	53	22.00	.27	22.27	4.11	2.97	49.15	4.24
5	186	359	1264	"	79	21.59	.50	22.09	4.74	16.69	62.99	6.32
6	[illegible]	6500	1066	"	111	21.50	.72	22.22	2.44	303.68	53.44	8.88
7	126	66	239	Idle	—	8.29	.03	8.32	0.94	1.29	[illegible]	—
8	151	[illegible]	1196	2100	136	27.41	.88	28.29	4.51	142.85	76.33	10.88
9	194	[illegible]	1298	"	108	27.41	.70	28.11	5.85	15.06	[illegible]	8.64
10	[illegible]	101	929	"	68	27.60	.48	28.08	5.52	5.97	58.85	5.44
11	[illegible]	76	561	"	33	28.05	.32	28.37	4.85	4.54	[illegible]	2.64
12	186	88	271	"	—	28.25	.16	28.41	[illegible]	5.26	17.37	—
13	128	101	260	Idle	—	8.29	.03	8.32	0.94	1.48	4.09	—
								TOTALS	45.80	509.19	488.56	49.68

RUN 2 - Right Engine Bank

MODE	C,H$_x$, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	128	114	176	Idle	—	8.42	.03	8.45	0.96	1.70	2.81	—
2	151	101	156	1600	—	22.05	.07	22.12	[illegible]	4.70	7.78	—
3	139	[illegible]	628	"	33	22.05	.25	[illegible]	[illegible]	1.78	[illegible]	2.64
4	151	[illegible]	1130	"	53	21.95	.27	[illegible]	[illegible]	1.98	56.90	4.24
5	162	[illegible]	1554	"	78	21.59	.49	[illegible]	[illegible]	14.87	[illegible]	6.24
6	139	[illegible]	1653	"	111	21.50	.72	[illegible]	[illegible]	[illegible]	32.36	8.88
7	116	126	151	Idle	—	8.29	.03	8.32	0.85	1.45	2.45	—
8	162	885	1576	2100	136	29.22	.88	30.10	4.81	[illegible]	96.10	10.88
9	151	126	1799	"	105	27.22	.68	27.90	4.45	7.40	113.11	8.40
10	139	[illegible]	1176	"	68	27.41	.48	27.89	4.09	3.70	75.25	5.44
11	151	[illegible]	717	"	37	27.60	[illegible]	[illegible]	4.45	[illegible]	45.15	2.96
12	162	[illegible]	[illegible]	"	—	27.79	.16	27.96	4.75	4.44	18.98	—
13	128	114	135	Idle	—	8.16	.03	8.19	0.93	1.65	2.09	—
								TOTALS	42.69	284.62	613.02	49.68

g/hr C_nH_{2n} = 0.0132 (ppm C,H$_x$)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.92	0.86
BSCO, g/bhp hr	10.25	5.73
BSNO, g/bhp hr	9.83	12.34

TABLE F-12. DETROIT DIESEL 8V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 105/GMC
Source: H. E. B.
Odom, Miles: 61, 485
Date Tested: 1-16-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29. 50	29. 46	29. 38
Dry Bulb, °F	77	65	64
Wet Bulb, °F	59	56	56

RUN 1 Left Bank of Engine

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	150	126	156	IDLE	———	8.24	.02	8.26	1.10	1.83	2.43	———
2	150	126	186	1600	———	21.25	.12	21.37	3.39	5.67	8.97	———
3	150	63	536	1600	32	21.17	.24	21.41	3.39	2.84	25.89	2.56
4	150	50	1004	1600	60	21.09	.39	21.48	3.40	2.26	48.65	4.80
5	150	101	1593	1600	88	21.11	.55	21.66	3.43	4.60	77.84	7.04
6	125	5,100	1369	1600	119	21.07	.80	21.87	2.89	234.67	67.54	9.52
7	138	76	207	IDLE	———	8.13	.02	8.15	.99	1.09	3.19	———
8	150	2,343	1478	2100	148	27.72	.96	28.68	4.54	141.38	95.63	11.84
9	138	101	1478	2100	108	27.39	.70	28.09	4.09	5.97	93.66	8.64
10	138	50	974	2100	72	27.20	.50	27.70	4.04	2.91	60.87	5.76
11	150	50	586	2100	42	27.20	.35	27.55	4.36	2.90	36.42	3.36
12	150	63	282	2100	———	27.12	.21	27.33	4.33	3.62	17.39	———
13	138	76	197	IDLE	———	8.11	.02	8.13	.99	1.09	3.03	———
								TOTALS	40.94	410.83	541.51	53.52

RUN 2 Right Bank of Engine

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	125	203	176	IDLE	———	8.28	.01	8.29	.92	2.97	2.76	———
2	150	139	197	1600	———	21.25	.12	21.37	3.39	6.25	9.50	———
3	150	63	599	1600	30	21.17	.23	21.40	3.39	2.84	28.92	2.40
4	150	50	1114	1600	61	21.09	.40	21.49	3.40	2.26	54.01	4.88
5	162	88	1797	1600	90	21.11	.56	21.67	3.71	4.01	87.85	7.20
6	112	4000	1574	1600	119	21.11	.80	21.91	2.59	184.39	77.80	9.52
7	125	114	271	IDLE	———	8.29	.02	8.31	.92	1.67	4.25	———
8	150	1731	1734	2100	148	27.72	.96	28.68	4.54	104.45	112.19	11.84
9	150	88	1693	2100	108	27.35	.70	28.05	4.44	5.19	107.13	8.64
10	150	50	1098	2100	72	27.20	.50	27.70	4.39	2.91	68.62	5.76
11	150	50	638	2100	40	27.20	.35	27.55	4.36	2.90	39.65	3.20
12	150	50	326	2100	———	27.06	.21	27.27	4.32	2.87	20.06	———
13	125	126	239	IDLE	———	8.11	.02	8.13	.90	1.81	3.67	———
								TOTALS	41.18	324.52	616.41	53.44

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	.76	.77
BSCO, g/bhp hr	7.68	6.07
BSNO, g/bhp hr	10.12	11.53

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TABLE F-13. DETROIT DIESEL 8V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 106/GMC
Source: H. E. B.
Odom, Miles: 48,487
Date Tested: 1-9-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.19	29.20	29.20
Dry Bulb, °F	70	70	67
Wet Bulb, °F	61	60	58

RUN 1 Left Engine Bank

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	125	178	156	IDLE	———	8.00	.03	8.03	.89	2.52	2.37	———
2	150	126	197	1600	———	21.49	.13	21.62	3.42	5.73	9.61	———
3	162	63	440	1600	30	21.58	.23	21.81	3.73	2.89	21.65	2.40
4	162	50	885	1600	68	21.53	.46	21.99	3.76	2.31	43.90	5.44
5	175	178	1369	1600	92	21.55	.58	22.13	4.09	8.29	68.35	7.36
6	112	5,500	1,333	1600	119	21.55	.80	22.35	2.64	258.63	67.21	9.52
7	12.5	101	2.82	IDLE	———	8.18	.03	8.21	.91	1.46	4.37	———
8	150	1,920	1554	2100	148	28.35	.97	29.32	4.64	118.44	102.79	11.84
9	162	76	1478	2100	108	28.05	.70	28.75	4.91	4.60	95.86	8.64
10	162	50	1004	2100	73	27.81	.52	28.33	4.85	2.98	64.17	5.84
11	165	50	638	2100	40	27.77	.35	28.12	4.91	2.96	40.47	3.20
12	[illegible]	76	348	2100	———	27.99	.22	28.21	5.11	4.51	22.15	———
13	139	101	260	IDLE	———	8.13	.03	8.16	1.00	1.45	4.01	———
								TOTALS	44.86	416.77	546.91	54.24

RUN 2 Right Engine Bank

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	139	203	12.5	IDLE	———	8.31	.02	8.33	1.02	2.98	1.97	———
2	150	165	145	1600	———	22.44	.13	22.57	3.58	7.84	7.38	———
3	139	76	487	1600	30	21.53	.23	21.76	3.17	3.48	23.91	2.40
4	138	50	827	1600	65	21.53	.42	21.95	3.20	2.31	40.95	5.20
5	138	152	1405	1600	90	21.55	.57	22.12	3.22	7.07	70.11	7.20
6	88	4,200	1,405	1600	119	21.50	.80	22.30	2.07	197.06	70.68	9.52
7	125	131	2.39	IDLE	———	8.16	.03	8.19	.91	2.01	3.70	———
8	112	1,700	1,613	2100	148	27.77	.97	28.74	3.40	102.80	104.58	11.84
9	12.5	101	1,516	2100	108	27.90	.70	28.60	3.78	6.08	97.81	8.64
10	125	50	1,020	2100	75	27.77	.52	28.29	3.73	2.98	65.10	6.00
11	125	50	664	2100	40	27.71	.35	28.06	3.70	2.95	42.03	3.20
12	150	76	326	2100	———	27.99	.22	28.21	4.47	4.51	20.75	———
13	138	139	218	IDLE	———	8.14	.03	8.17	1.00	2.00	3.37	———
								TOTALS	37.25	344.07	552.31	54.00

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.83	0.69
BSCO, g/bhp hr	7.68	6.37
BSNO, g/bhp hr	10.08	10.23

TABLE F-14. DETROIT DIESEL 8V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 107/GMC
Source: H. E. B.
Odom, Miles: 61,050
Date Tested: 1-23-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.01	29.02	29.02
Dry Bulb, °F	70	73	72
Wet Bulb, °F	64	66	66

RUN 1 *Left Bank Engine*

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	150	126	239	IDLE	—	8.21	.03	8.24	1.09	1.83	3.72	—
2	138	76	218	1600	—	21.14	.13	21.27	3.10	3.40	10.46	—
3	150	38	487	1600	30	21.29	.23	21.52	3.41	1.72	23.64	2.40
4	150	25	914	1600	62	21.22	.40	21.62	3.42	1.14	44.58	4.96
5	162	178	1,441	1600	90	20.99	.56	21.55	3.69	8.07	70.06	7.20
6	125	6,000	1,298	1600	119	20.96	.79	21.75	2.87	274.57	63.69	9.52
7	138	63	271	IDLE	—	8.10	.03	8.13	.99	.90	4.16	—
8	125	2,048	1,351	2100	146	27.48	.95	28.43	3.75	122.50	86.65	11.68
9	150	76	1,316	2100	109	27.49	.70	28.19	4.47	4.51	83.69	8.72
10	138	25	974	2100	73	27.38	.50	27.88	4.06	1.47	61.26	5.84
11	125	25	586	2100	37	27.38	.33	27.71	3.66	1.46	36.63	2.96
12	125	25	337	2100	—	27.30	.20	27.50	3.63	1.45	20.91	—
13	150	63	303	IDLE	—	8.10	.03	8.13	1.08	.90	4.65	—
								TOTALS	39.22	423.92	514.10	53.28

RUN 2 *Right Bank Engine*

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	188	152	96	IDLE	—	8.28	.03	8.91	1.48	2.40	1.62	—
2	175	114	156	1600	—	21.30	.13	21.43	3.96	5.14	7.54	—
3	162	50	475	1600	33	21.22	.25	21.47	3.67	2.26	23.01	2.64
4	200	25	885	1600	58	21.11	.38	21.49	4.54	1.13	42.91	4.64
5	200	50	1,535	1600	91	21.04	.58	21.62	4.67	2.27	74.87	7.28
6	150	4,000	1,497	1600	120	20.96	.80	21.76	3.45	183.13	73.49	9.60
7	175	76	145	IDLE	—	8.10	.03	8.13	1.26	1.09	2.23	—
8	175	1,189	1,554	2100	147	27.44	.96	28.40	5.25	71.05	99.57	11.76
9	188	38	1,441	2100	108	27.49	.70	28.19	5.60	2.33	91.64	8.64
10	175	25	1,020	2100	75	27.43	.52	27.95	5.17	1.47	64.32	6.00
11	188	25	612	2100	35	27.29	.33	27.62	5.48	1.45	38.13	2.80
12	188	38	326	2100	—	27.24	.21	27.45	5.45	2.19	20.19	—
13	175	88	145	IDLE	—	8.08	.03	8.11	1.26	1.26	2.22	—
								TOTALS	51.24	277.17	541.74	53.36

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.74	0.96
BSCO, g/bhp hr	7.96	5.19
BSNO, g/bhp hr	9.64	10.15

TABLE F-15. DETROIT DIESEL 8V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 405/IHC
Source: ABC Lease
Odom, Miles: 59,990
Date Tested: 12-28-70

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.01	-	29.05
Dry Bulb, °F	72	-	74
Wet Bulb, °F	68	-	70

RUN 1 - Left Engine Bank

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	139	203	115	Idle	———	8.52	.03	8.55	1.05	3.06	1.86	———
2	139	152	135	1600	———	22.30	.10	22.40	3.29	7.16	6.42	———
3	139	50	487	"	33	22.30	.25	22.55	3.31	2.37	24.78	2.64
4	139	38	856	"	55	22.20	.36	22.56	3.31	1.80	47.57	4.40
5	139	63	1287	"	84	21.95	.53	22.48	3.30	2.98	76.24	6.72
6	162	5700	1653	"	110	21.50	.70	22.20	3.60	266.24	82.19	8.80
7	139	165	145	Idle	———	8.29	.03	8.32	1.02	2.42	2.28	———
8	162	640	1593	2100	134	28.03	.86	28.89	4.94	38.90	103.87	10.72
9	175	88	1405	"	105	28.03	.68	28.71	5.71	5.72	91.00	8.40
10	162	50	885	"	68	28.22	.48	28.70	4.91	3.02	57.30	5.44
11	162	50	612	"	36	28.05	.33	28.38	4.86	2.99	39.18	2.88
12	162	76	260	"	———	28.25	.20	28.45	4.87	4.55	16.69	———
13	139	165	145	Idle	———	8.40	.03	8.43	1.04	2.45	2.31	———
								TOTALS	45.01	343.26	542.75	50.00

RUN 2 - Right Engine Bank

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	128	165	303	Idle	———	8.52	.03	8.55	0.97	2.49	4.89	———
2	151	126	239	1600	———	22.30	.11	22.41	3.57	5.94	12.08	———
3	151	50	617	"	33	22.30	.25	22.55	3.60	2.37	33.12	2.64
4	151	38	1066	"	55	22.20	.36	22.56	3.60	1.80	54.25	4.40
5	128	76	1713	"	84	21.95	.53	22.48	3.04	3.59	86.87	6.72
6	139	5500	1861	"	110	21.85	.70	22.55	3.31	260.95	94.67	8.80
7	151	165	326	Idle	———	8.43	.03	8.46	1.13	2.46	5.21	———
8	128	847	1818	2100	135	28.13	.88	29.01	3.92	51.70	118.98	10.80
9	128	126	1633	"	105	28.13	.68	28.81	3.89	7.64	106.14	8.40
10	139	76	1095	"	68	27.86	.48	28.34	4.16	4.53	66.17	5.44
11	151	63	744	"	36	28.05	.33	28.38	4.53	3.76	47.63	2.88
12	162	101	314	"	———	28.25	.20	28.45	4.87	6.05	20.15	———
13	139	152	337	Idle	———	8.40	.03	8.43	1.04	2.26	5.37	———
								TOTALS	41.63	355.54	655.53	50.08

g/hr C_nH_{2n} = 0.0132 (ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.90	0.83
BSCO, g/bhp hr	6.87	7.10
BSNO, g/bhp hr	10.86	13.09

TABLE F-16. DETROIT DIESEL 8V-71 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: V591/MCI
Source: Kerrville Bus Co.
Odom, Miles: 59,234
Date Tested: 6-2-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.22	29.22	29.23
Dry Bulb, °F	94	96	96
Wet Bulb, °F	78	76	75

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	100	50	239	Idle	—	8.50	.05	8.55	.76	.75	3.86	—
2	100	25	207	1260	—	19.84	.20	20.04	2.12	1.05	9.36	—
3	125	13	348	"	44	19.68	.35	20.03	2.64	.55	15.13	[illegible]
4	125	13	612	"	86	19.60	.57	20.17	2.66	.55	27.95	6.88
5	175	190	959	"	130	19.44	.84	20.28	3.75	8.11	43.19	10.40
6	150	10,310	856	"	180	19.20	1.18	20.38	3.23	442.09	39.36	14.40
7	138	13	303	Idle	—	8.50	.06	8.56	1.04	.20	4.90	—
8	163	1762	1098	2100	272	34.80	1.75	36.55	6.29	155.50	90.54	21.76
9	150	[illegible]	[illegible]	[illegible]	300	34.88	1.30	[illegible]	[illegible]	6.70	[illegible]	[illegible]
10	138	13	664		132	35.04	.75	35.97	[illegible]	.98	53.91	[illegible]
11	125	13	337	"	68	35.04	.65	35.69	[illegible]	.78	29.13	5.44
12	125	38	[illegible]	"	—	[illegible]	.50	[illegible]	[illegible]	2.85	19.25	—
13	[illegible]	[illegible]		[illegible]	—	[illegible]	[illegible]			.75	[illegible]	—
								TOTALS	[illegible]	[illegible]	[illegible]	[illegible]

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	100	63	239	Idle	—	8.50	[illegible]	8.55	.76	.95	[illegible]	—
2	100	50	218	[illegible]	—	19.84	.21	[illegible]	2.12	2.11	9.86	—
3	113	38	382	"	43	19.68	.35	[illegible]	2.39	1.60	17.26	3.44
4	150	50	664	"	84	19.60	.56	20.16	3.19	2.12	30.30	6.72
5	188	216	1020	"	[illegible]	19.44	.84	[illegible]	4.03	9.22	46.67	10.40
6	163	11,152	899	"	[illegible]	19.20	1.18	[illegible]	2.51	472.90	41.33	14.40
7	113	63	282	Idle	—	8.50	.05	8.55	.75	.75	4.55	—
8	150	2048	1147	2100	270	34.80	1.73	36.53	[illegible]	157.41	94.53	21.60
9	138	165	1082	"	300	34.88	1.30	36.18	[illegible]	12.56	88.32	16.00
10	125	38	703	"	134	35.04	.76	36.00	4.75	2.88	57.09	10.72
11	125	25	382	"	66	35.04	.64	[illegible]	4.71	1.88	30.75	5.28
12	[illegible]	38	260	"	—	35.20	.47	35.67	4.71	2.85	20.92	—
13	38	[illegible]	249	Idle	—	8.50	.05	8.55	1.04	.75	4.02	—
								TOTALS	[illegible]	669.18	[illegible]	[illegible]

$g/hr\ C_nH_{2n} = 0.0132(ppm\ C_1H_x)(EXH.FLOW, lb/min)(Weight\ Factor)$

$g/hr\ CO = 0.0263(ppm\ CO)(EXH.FLOW, lb/min)(Weight\ Factor)$

$g/hr\ NO = 0.0282(ppm\ NO)(EXH.FLOW, lb/min)(Weight\ Factor)$

	RUN 1	RUN 2
BSHC, g/bhp hr	.49	.49
BSCO, g/bhp hr	6.75	7.36
BSNO, g/bhp hr	4.71	5.07

TABLE F-17. DETROIT DIESEL 6V-53N 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: H-3/IHC
Source: Roegelein Provision Co.
Odom, Miles: 22,754
Date Tested: 7-3-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.21	29.21	29.18
Dry Bulb, °F	86	87	88
Wet Bulb, °F	74	74	75

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	150	101	326	Idle	———	7.40	.04	7.44	.99	1.32	4.58	———
2	200	76	249	1800	———	30.80	.17	30.97	6.54	4.95	17.40	———
3	225	50	512	"	33	30.20	.30	30.50	7.25	3.21	35.23	2.64
4	225	76	944	"	75	29.70	.52	30.22	7.18	4.83	64.36	6.00
5	250	654	1369	"	114	29.10	.74	29.84	7.88	41.06	92.16	9.12
6	225	6721	1264	"	148	28.40	1.02	29.42	6.99	416.03	83.89	11.84
7	175	76	416	Idle	———	7.40	.04	7.44	1.15	1.00	5.85	———
8	225	1608	1633	2600	195	42.50	1.33	43.83	10.41	148.29	161.47	15.60
9	250	178	1516	"	149	42.90	1.03	43.93	11.60	16.45	150.24	11.93
10	250	38	1066	"	98	43.40	.73	44.13	11.65	3.53	106.13	7.54
11	275	25	586	"	52	43.80	.52	44.32	12.87	2.33	58.57	4.16
12	275	25	314	"	———	44.00	.36	44.36	12.98	2.33	31.47	———
13	157	63	405	Idle	———	7.40	.05	7.45	1.23	.83	5.70	———
								TOTALS	98.62	646.16	817.02	67.1[illegible]

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	175	114	348	Idle	———	7.40	.04	7.44	1.15	1.49	4.8[illegible]	———
2	225	88	260	1800	———	30.80	.17	30.97	7.36	5.73	18.17	———
3	225	76	536	"	26	30.20	.27	30.47	7.24	4.87	36.84	2.08
4	250	88	989	"	80	29.70	.55	30.25	7.99	5.60	67.49	6.40
5	275	903	1405	"	93	29.10	.72	29.82	8.66	56.66	94.52	7.44
6	225	6643	1264	"	149	28.40	1.03	29.43	6.99	411.34	83.93	11.92
7	175	76	440	Idle	———	7.40	.04	7.44	1.15	1.00	6.19	———
8	250	1441	1653	2600	192	42.50	1.30	43.80	11.56	132.80	163.34	15.36
9	250	178	1535	"	153	42.90	1.04	43.94	11.60	16.46	152.16	12.24
10	262	50	1114	"	98	43.40	.74	44.14	12.21	4.64	110.93	7.84
11	275	38	586	"	53	43.80	.53	44.33	12.87	3.54	58.61	4.24
12	2[illegible]	38	337	"	———	44.00	.34	44.34	13.44	3.54	33.71	———
13	157	76	416	Idle	———	7.40	.03	7.43	1.23	1.00	5.84	———
								TOTALS	103.45	648.67	836.61	67.52

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.43	1.53
BSCO, g/bhp hr	9.35	9.61
BSNO, g/bhp hr	11.82	12.39

TABLE F-18. DETROIT DIESEL 6V-53N 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: H-4/IHC
Source: Roegelein Provision Co.
Odom, Miles: 20,402
Date Tested: 7-10-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.27	29.27	29.27
Dry Bulb, °F	96	98	100
Wet Bulb, °F	87	89	90

RUN 1

MODE	C, Hx, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr CnH2n (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	238	139	337	Idle	———	7.40	.05	7.45	1.57	1.82	4.74	———
2	262	101	218	1800	———	30.80	.18	30.98	8.57	6.58	15.24	———
3	262	88	428	"	35	30.20	.31	30.51	8.44	5.65	29.46	2.80
4	275	126	785	"	75	29.70	.52	30.22	8.78	8.01	53.52	6.00
5	300	373	1147	"	113	29.10	.75	29.85	9.46	23.50	77.24	9.04
6	275	5,336	1196	"	143	28.40	.98	29.38	8.53	342.21	77.77	11.44
7	200	114	492	Idle	———	7.40	.05	7.45	1.32	1.50	6.93	———
8	258	913	1562	2600	194	42.50	1.32	43.82	13.33	83.25	154.42	[illegible]
9	300	152	1351	"	149	42.90	1.03	43.93	13.92	14.05	133.87	11.92
10	300	76	856	"	98	43.40	.74	44.14	13.98	7.06	85.24	7.84
11	288	76	524	"	46	43.80	.48	44.28	13.47	7.08	52.25	3.68
12	300	76	337	"	———	44.00	.35	44.35	14.05	7.09	33.42	———
13	212	126	382	Idle	———	7.40	.05	7.45	1.40	1.65	5.38	———
								TOTALS	116.82	509.45	731.46	68.24

RUN 2

MODE	C, Hx, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr CnH2n (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	225	114	337	Idle	———	7.40	.05	7.45	1.48	1.50	4.74	———
2	238	88	239	1800	———	30.80	.19	30.99	7.79	5.74	16.71	———
3	250	76	464	"	36	30.20	.32	30.52	8.06	4.88	31.95	2.88
4	262	101	827	"	74	29.70	.51	30.21	8.36	6.42	56.36	5.92
5	312	346	1247	"	109	29.10	.73	29.83	9.83	21.72	83.92	8.72
6	262	5,257	1281	"	141	28.40	.97	29.37	8.13	324.85	84.88	11.28
7	188	88	416	Idle	———	7.40	.05	7.45	1.24	1.16	5.86	———
8	250	974	1554	2600	193	42.50	1.31	43.71	11.57	77.78	153.59	15.44
9	275	139	1441	"	146	42.90	1.00	43.90	12.75	12.84	142.71	11.68
10	262	50	870	"	96	43.40	.73	44.13	12.21	4.64	86.61	7.68
11	275	38	536	"	49	43.80	.50	44.30	12.86	3.54	53.57	3.92
12	288	50	326	"	———	44.00	.35	44.35	13.49	4.67	32.62	———
13	200	101	492	Idle	———	7.40	.05	7.45	1.32	1.33	6.93	———
								TOTALS	109.09	483.07	760.45	67.52

g/hr C_nH_{2n} = 0.0132 (ppm-C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263 (ppm-CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782 (ppm-NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.71	1.61
BSCO, g/bhp hr	7.46	7.15
BSNO, g/bhp hr	10.71	11.26

TABLE F-19. DETROIT DIESEL 6V-53N 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: H-8/IHC
Source: Roegelein Provision Co.
Odom, Miles: 26,664
Date Tested: 8-7-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.29	29.29	29.27
Dry Bulb, °F	87	87	91
Wet Bulb, °F	75	75	76

RUN 1

MODE	C_1H_n, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	200	165	536	Idle	——	7.40	.07	7.47	1.32	2.17	7.57	——
2	250	76	260	1800	——	30.80	.17	30.97	8.18	4.95	18.17	——
3	238	38	512	"	36	30.20	.31	30.51	7.67	2.44	35.24	2.88
4	250	50	914	"	72	29.70	.50	30.20	7.97	3.18	62.27	5.76
5	300	439	1,351	"	105	29.10	.70	29.80	9.44	27.53	90.83	8.40
6	312	7,362	1,230	"	142	28.40	.98	29.38	9.68	455.09	81.53	11.36
7	212	126	730	Idle	——	7.40	.08	7.48	1.40	1.66	10.32	——
8	350	1,547	1,673	2600	188	42.50	1.26	43.76	16.17	142.43	165.16	15.04
9	312	126	1,554	"	142	42.90	.98	43.88	14.46	11.63	153.94	11.36
10	312	25	1,035	"	89	43.40	.69	44.09	14.53	2.32	102.95	7.12
11	325	25	638	"	49	43.80	.50	44.30	15.20	2.33	63.76	3.92
12	350	25	359	"	——	44.00	.33	44.33	16.38	2.33	35.90	——
13	212	101	561	Idle	——	7.40	.07	7.47	1.40	1.33	7.91	——
								TOTALS	123.80	659.39	835.45	65.84

RUN 2

MODE	C_1H_n, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	200	190	561	Idle	——	7.40	.07	7.47	1.32	2.50	7.91	——
2	250	88	260	1800	——	30.80	.18	30.98	8.18	5.74	18.17	——
3	250	50	574	"	38	30.20	.32	30.52	8.06	3.21	39.52	3.04
4	275	63	1,004	"	72	29.70	.50	30.20	8.77	4.00	68.40	5.76
5	312	627	1,478	"	109	29.10	.72	29.82	9.82	39.34	99.13	8.72
6	288	7,280	1,261	"	142	28.40	.98	29.38	8.94	450.02	83.78	11.36
7	200	165	744	Idle	——	7.40	.08	7.48	1.32	2.17	10.57	——
8	325	1,516	1,713	2600	187	42.50	1.25	43.75	15.02	139.55	169.07	14.96
9	312	139	1,633	"	143	42.90	.99	43.89	14.46	12.84	161.69	11.44
10	312	25	1,066	"	92	43.40	.70	44.10	14.53	2.32	106.06	7.36
11	312	25	612	"	49	43.80	.48	44.28	14.59	2.33	61.14	3.92
12	325	25	359	"	——	44.00	.33	44.33	15.21	2.33	35.90	——
13	212	101	574	Idle	——	7.40	.07	7.47	1.40	1.33	8.10	——
								TOTALS	121.62	667.68	867.68	66.56

g/hr C_nH_{2n} = 0.0132(ppm C_1H_n)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.88	1.83
BSCO, g/bhp hr	10.02	10.03
BSNO, g/bhp hr	12.68	13.06

TABLE F-20. DETROIT DIESEL 6V-53N 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: H-10/IHC
Source: Roegelein Provision Co.
Odom, Miles: 23,926
Date Tested: 8-24-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.19	29.18	29.20
Dry Bulb, °F	99	104	103
Wet Bulb, °F	79	80	78

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	200	88	303	Idle	———	7.40	.05	7.45	1.32	1.16	4.27	———
2	200	76	239	1800	———	30.80	.18	30.98	6.54	4.95	16.70	———
3	225	50	536	"	44	30.20	.35	30.55	7.26	3.21	36.94	3.52
4	238	88	785	"	73	29.70	.50	30.20	7.59	5.59	53.48	5.84
5	275	373	1,179	"	109	29.10	.72	29.82	8.66	23.40	79.32	8.72
6	225	6040	1,147	"	139	28.40	.95	29.35	6.97	372.98	75.95	11.12
7	212	76	393	Idle	———	7.40	.05	7.45	1.40	1.00	5.53	———
8	250	1160	1,516	2600	187	42.50	1.25	43.75	11.55	106.78	149.63	14.96
9	250	88	1,333	"	136	42.90	.95	43.85	11.58	8.12	131.87	10.88
10	262	25	870	"	93	43.40	.71	44.11	12.20	2.32	86.58	7.44
11	262	25	549	"	49	43.80	.50	44.30	12.26	2.33	54.87	3.92
12	288	38	337	"	———	44.00	.35	44.35	13.49	3.55	33.72	———
13	212	76	370	Idle	———	7.40	.05	7.45	1.40	1.00	5.21	———
								TOTALS	102.22	536.39	734.07	66.40

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	212	126	326	Idle	———	7.40	.04	7.44	1.39	1.65	4.58	———
2	212	101	260	1800	———	30.80	.18	30.98	6.94	6.58	18.17	———
3	238	76	574	"	44	30.20	.35	30.55	7.68	4.89	39.56	3.52
4	250	101	841	"	69	29.70	.48	30.18	7.97	6.41	57.26	5.52
5	288	333	1,264	"	105	29.10	.70	29.80	9.06	20.98	84.98	8.40
6	250	6113	1,230	"	139	28.40	.95	29.35	7.75	377.49	81.44	11.12
7	212	101	416	Idle	———	7.40	.05	7.45	1.40	1.33	5.96	———
8	225	1366	1,593	2600	187	42.50	1.25	43.75	10.40	125.74	157.23	14.96
9	250	126	1423	"	139	42.90	.96	43.86	11.58	11.63	140.80	11.12
10	250	50	944	"	90	43.40	.70	44.10	11.64	4.64	93.92	7.20
11	275	50	574	"	46	43.80	.48	44.28	12.86	4.66	57.34	3.68
12	300	50	348	"	———	44.00	.35	44.35	14.05	4.67	34.82	———
13	212	101	393	Idle	———	7.40	.05	7.45	1.40	1.33	5.53	———
								TOTALS	104.12	571.90	781.49	65.52

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.54	1.59
BSCO, g/bhp hr	8.08	8.73
BSNO, g/bhp hr	11.06	11.93

TABLE F-21. DETROIT DIESEL 6V-53N 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: H-16/IHC
Source: Roegelein Provision Co.
Odom, Miles: 21,053
Date Tested: 7-24-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.10	29.10	29.04
Dry Bulb, °F	95	98	95
Wet Bulb, °F	85	85	79

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	225	126	303	Idle	———	7.40	.04	7.44	1.48	1.65	4.26	———
2	225	76	207	1800	———	30.80	.18	30.98	7.36	4.95	14.47	———
3	212	50	428	"	30	30.20	.29	30.49	6.83	3.21	29.44	2.40
4	225	50	827	"	72	29.70	.50	30.20	7.18	3.18	56.34	5.76
5	287	281	1281	"	106	29.10	.70	29.80	9.03	17.62	86.12	8.48
6	312	6490	1264	"	144	28.40	.99	29.39	9.68	401.32	83.81	11.52
7	200	88	393	Idle	———	7.40	.04	7.44	1.32	1.15	5.52	———
8	300	1016	1593	2600	190	42.50	1.28	43.78	13.87	93.57	157.34	15.20
9	287	101	1423	"	146	42.90	1.00	43.90	13.30	9.33	140.93	11.68
10	262	38	870	"	86	43.40	.68	44.08	12.20	3.52	86.52	6.88
11	262	25	512	"	42	43.80	.49	44.29	12.25	2.33	51.16	3.36
12	275	38	303	"	———	44.00	.34	44.34	12.88	3.55	30.31	———
13	225	101	359	Idle	———	7.40	.05	7.45	1.48	1.32	5.05	———
								TOTALS	108.86	546.73	751.27	65.28

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	225	139	314	Idle	———	7.40	.04	7.44	1.48	1.82	4.47	———
2	212	101	217	1800	———	30.80	.18	30.98	5.81	6.58	15.17	———
3	200	88	463	"	29	30.20	.28	30.48	6.44	5.61	31.84	2.32
4	225	88	870	"	72	29.70	.50	30.20	7.18	5.59	59.27	5.76
5	300	386	1333	"	106	29.10	.70	29.80	9.44	24.20	89.62	8.48
6	312	6490	1281	"	144	28.40	.99	29.39	9.68	401.32	84.94	11.52
7	200	126	393	Idle	———	7.40	.04	7.44	1.32	1.65	5.52	———
8	312	1074	1633	2600	189	42.50	1.27	43.77	14.42	98.91	161.25	15.12
9	287	126	1441	"	147	42.90	1.00	43.90	13.30	11.64	142.71	11.76
10	250	63	914	"	87	43.40	.68	44.08	11.64	5.84	90.89	6.96
11	250	50	512	"	46	43.80	.48	44.28	11.69	4.66	51.15	3.68
12	262	76	292	"	———	44.00	.35	44.35	12.27	7.09	29.22	———
13	200	126	370	Idle	———	7.40	.05	7.45	1.32	1.65	5.21	———
								TOTALS	105.99	576.59	771.21	65.60

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.67	1.62
BSCO, g/bhp hr	8.38	8.77
BSNO, g/bhp hr	11.51	11.76

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TABLE F-22. CUMMINS NH-250 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 21/Kenworth
Source: Alamo Transportation
Odom, Miles: 50,738
Date Tested: 9-16-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	9.14	29.14	-
Dry Bulb, °F	99	110	-
Wet Bulb, °F	78	79	-

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	138	50	57	Idle	———	8.30	.06	8.36	[illegible]	0.74	[illegible]	———
2	163	76	47	1500	———	21.83	.13	21.96	[illegible]	[illegible]	2.33	———
3	138	88	271	"	52	21.72	.37	22.09	[illegible]	[illegible]	13.51	4.16
4	138	178	574	"	100	21.38	.62	22.00	3.21	[illegible]	[illegible]	8.00
5	150	691	1066	"	144	20.83	.88	21.71	[illegible]	31.11	[illegible]	11.52
6	37	6413	1478	"	192	20.00	1.23	21.23	[illegible]	286.46	[illegible]	[illegible]
7	12.5	88	86	Idle	———	8.30	.06	8.36	[illegible]	1.30	1.36	———
8	37	3603	1130	2100	244	28.83	1.60	30.43	1.17	[illegible]	77.57	19.52
9	12.5	425	744	"	190	29.98	[illegible]	31.08	4.10	[illegible]	58.17	[illegible]
10	100	178	459	"	122	30.33	.80	31.13	3.29	11.66	34.20	[illegible]
11	100	114	166	"	58	30.52	.48	31.00	[illegible]	7.44	11.61	4.64
12	12	76	76	"	———	30.58	.18	30.76	[illegible]	[illegible]	[illegible]	———
13	[illegible]	76	66	Idle	———	8.30	.06	8.36	[illegible]	[illegible]	1.04	———
								TOTALS	[illegible]	612.76	351.47	89.16

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	100	136	57	Idle	———	8.30	.06	8.36	0.74	1.96	[illegible]	———
2	162	139	66	1500	———	21.83	.13	21.96	[illegible]	6.42	[illegible]	———
3	112	152	282	"	49	21.73	.35	22.08	2.61	7.66	14.95	3.84
4	125	255	664	"	120	21.17	.72	21.89	[illegible]	11.75	32.81	9.60
5	12.5	709	1179	"	146	[illegible]	[illegible]	21.73	2.87	32.42	57.80	11.68
6	25	4853	1516	"	192	20.00	1.23	21.23	0.56	216.77	72.61	15.36
7	12.5	126	96	Idle	———	8.30	.06	8.36	0.12	1.86	1.52	———
8	25	3142	1146	2100	246	28.75	1.62	30.37	0.80	200.77	78.52	19.68
9	112	412	771	"	172	30.07	1.08	31.15	3.68	[illegible]	54.18	13.76
10	87	216	500	"	119	30.33	[illegible]	31.11	2.96	14.14	35.09	9.52
11	87	165	282	"	58	30.53	.48	31.01	2.85	10.77	19.73	4.64
12	200	165	115	"	———	30.58	.20	30.78	1.50	10.49	7.79	———
13	112	114	96	Idle	———	8.30	.06	8.36	[illegible]	1.68	1.52	———
								TOTALS	31.87	513.19	380.01	88.08

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.41	0.36
BSCO, g/bhp hr	7.02	6.17
BSNO, g/bhp hr	3.99	4.31

TABLE F-23. CUMMINS NH-250 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 22/White
Source: Alamo Transportation
Odom, Miles: 71,829
Date Tested: 10-9-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.40	29.40	29.37
Dry Bulb, °F	83	88	-
Wet Bulb, °F	70	73	-

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	125	126	96	Idle	—	8.20	.06	8.26	0.91	1.83	1.50	—
2	150	126	96	1500	—	21.83	.17	22.00	3.48	5.83	4.77	—
3	112	139	217	"	45	21.73	.33	22.06	2.61	6.45	10.80	3.60
4	150	268	536	"	93	21.43	.58	22.01	3.49	12.41	26.61	7.44
5	137	627	1,098	"	148	20.78	.92	21.70	3.14	28.63	53.75	11.84
6	25	4,462	1,554	"	193	19.97	1.25	21.22	0.56	199.21	74.39	15.44
7	75	126	135	Idle	—	8.20	.06	8.26	0.55	1.83	2.11	—
8	12	2,648	1,098	2100	246	28.72	1.63	30.35	0.39	169.09	75.18	19.68
9	87	465	690	"	168	30.10	1.07	31.17	2.86	30.50	48.52	13.44
10	75	294	452	"	114	30.37	.75	31.12	2.46	19.25	31.73	9.12
11	75	190	249	"	50	30.53	.45	30.98	2.45	12.39	17.40	4.00
12	150	178	156	"	—	30.58	.28	30.86	4.89	11.56	10.86	—
13	87	152	125	Idle	—	8.20	.06	8.26	0.64	2.21	1.95	—
								TOTALS	28.43	501.19	359.57	84.56

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	112	126	115	Idle	—	8.20	.06	8.26	0.82	1.83	1.79	—
2	125	126	115	1500	—	21.83	.17	22.00	2.90	5.83	5.71	—
3	100	152	239	"	45	21.73	.33	22.06	2.33	7.05	11.89	3.60
4	112	307	664	"	93	21.43	.58	22.01	2.60	14.22	32.97	7.44
5	112	627	1,196	"	150	20.77	.93	21.70	2.57	28.63	58.55	12.00
6	12	4,591	1,633	"	192	19.97	1.23	21.20	0.27	204.78	78.10	15.36
7	75	152	176	Idle	—	8.20	.06	8.26	0.55	2.21	2.75	—
8	12	2,511	974	2100	243	28.82	1.60	30.42	0.39	160.71	66.84	19.44
9	75	465	730	"	168	30.10	1.07	31.17	2.47	30.50	51.33	13.44
10	75	268	475	"	114	30.37	.75	31.12	2.46	17.55	33.35	9.12
11	75	203	271	"	46	30.55	.40	30.95	2.45	13.22	18.92	3.68
12	150	178	166	"	—	30.58	.30	30.88	4.89	11.56	11.56	—
13	87	152	145	Idle	—	8.20	.06	8.26	0.64	2.21	2.26	—
								TOTALS	25.74	500.30	376.02	84.08

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.34	0.30
BSCO, g/bhp hr	5.93	5.95
BSNO, g/bhp hr	4.25	4.47

TABLE F-24. CUMMINS NH-250 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 62/Ford
Source: H. E. B.
Odom, Miles: 161,645
Date Tested: 9-11-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.04	29.05	29.05
Dry Bulb, °F	86	85	87
Wet Bulb, °F	75	75	75

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	150	63	76	Idle	—	8.50	.03	8.53	1.13	0.95	1.22	—
2	150	88	86	1500	—	21.83	.13	21.96	3.48	4.07	4.26	—
3	125	76	292	"	45	21.75	.33	22.08	2.91	3.53	14.55	3.60
4	125	139	599	"	97	21.42	.60	22.02	2.91	6.44	29.76	7.76
5	112	1,103	1,163	"	152	20.75	.93	21.68	2.56	50.31	56.88	12.16
6	62	5,966	1,281	"	202	19.75	1.33	21.08	1.38	264.61	60.92	16.16
7	100	38	106	idle	—	8.50	.05	8.55	0.76	0.57	1.71	—
8	50	1,920	1,066	2100	273	27.90	1.86	29.76	1.57	120.22	71.57	21.84
9	125	791	885	"	204	29.67	.30	30.97	4.09	51.54	61.83	16.32
10	88	178	574	"	134	30.27	.87	31.14	2.89	11.66	40.33	10.72
11	88	101	303	"	68	30.50	.53	31.03	2.88	6.59	21.21	5.44
12	125	101	135	"	—	30.59	.28	30.87	4.07	6.56	9.40	—
13	100	38	106	Idle	—	8.50	.03	8.53	0.75	0.57	1.71	—
								TOTALS	31.39	527.62	375.34	94.00

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	100	114	96	Idle	—	8.50	.03	8.53	0.75	1.71	1.55	—
2	112	139	115	1500	—	21.83	.13		2.60	6.42	5.70	—
3	100	139	326	"	48	21.73	.35	22.08	2.33	6.46	16.24	3.84
4	100	178	651	"	91	21.45	.57	[illegible]	2.33	8.25	32.34	7.28
5	100	903	1,230	"	155	20.68	.96	21.64	2.29	41.11	60.05	12.40
6	38	5,121	1,333	"	202	19.75	1.33	21.08	0.85	227.13	63.39	16.16
7	88	88	115	Idle	—	8.50	.13	8.63	0.66	1.32	1.85	—
8	25	1,920	1,082	2,100	274	27.94	1.87	29.81	0.79	120.42	72.77	21.92
9	100	709	899	"	206	29.63	1.31	30.94	3.27	46.15	62.75	16.48
10	75	242	612	"	143	30.23	.92	31.05	2.46	15.81	42.87	11.44
11	75	152	314	"	65	30.50	.52	31.02	2.46	9.92	21.97	5.20
12	125	152	156	"	—	30.58	.27	30.85	4.07	9.87	10.86	—
13	88	101	115	Idle	—	8.50	.03	8.53	0.66	1.52	1.85	—
								TOTALS	23.19	496.09	394.19	94.72

		RUN 1	RUN 2
g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)	BSHC, g/bhp hr	0.33	0.24
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)	BSCO, g/bhp hr	5.61	5.24
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)	BSNO, g/bhp hr	3.99	4.16

TABLE F-25. CUMMINS NH-250 13 MODE GASEOUS EMISSIONS SUMMARY

		Inlet Conditions	Before	Between	After
Vehicle No/Make:	15743/IHC	Bar, in Hg Corr	29.12	29.13	-
Source:	Ryder Lease	Dry Bulb, °F	72	69	-
Odom, Miles:	76,652	Wet Bulb, °F	57	57	-
Date Tested:	3-18-71				

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	112	88	86	Idle	0	8.50	.05	8.55	.85	1.33	1.39	0
2	150	114	106	1500	0	21.83	.13	21.96	3.48	5.27	5.25	0
3	125	114	282	"	44	21.83	.33	22.16	2.93	5.32	14.10	3.52
4	125	178	651	"	98	21.33	.61	21.94	2.90	8.22	32.22	7.84
5	100	294	1114	"	142	20.91	.86	21.77	2.30	13.47	54.71	11.36
6	38	2563	1755	"	208	19.50	1.40	20.90	.84	112.70	82.75	16.64
7	100	76	135	Idle	0	8.50	.05	8.55	.76	1.15	2.18	0
8	25	1794	1196	2100	234	29.03	1.53	30.56	.81	115.35	82.46	18.72
9	75	281	771	"	174	30.05	1.10	31.15	2.47	18.42	54.18	13.92
10	75	178	475	"	110	30.38	.73	31.11	2.46	11.65	33.34	8.80
11	100	152	292	"	61	30.52	.50	31.02	3.28	9.92	20.43	4.88
12	138	139	156	"	0	30.58	.20	30.78	4.49	9.00	10.83	0
13	112	76	115	Idle	0	8.50	.05	8.55	.85	1.15	1.86	0
								TOTALS	25.96	312.95	395.70	85.69

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1					0							—
2					0							—
3												
4												
5												
6												
7					0							—
8												
9												
10												
11												
12					0							—
13					0							—
								TOTALS				

Formula		RUN 1	RUN 2
g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)	BSHC, g/bhp hr	.30	
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)	BSCO, g/bhp hr	3.65	
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)	BSNO, g/bhp hr	4.62	

TABLE F-26. CUMMINS NH-250 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 15744/IHC
Source: Ryder Lease
Odom, Miles: 77,254
Date Tested: 3-19-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.56	-	29.58
Dry Bulb, °F	78	-	80
Wet Bulb, °F	54	-	55

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	112	101	96	Idle	—	8.50	.05	8.55	.85	1.52	1.55	—
2	125	126	96	1500	—	21.83	.13	21.96	2.90	5.82	4.76	—
3	112	126	228	"	42	21.75	.32	22.07	2.61	5.85	11.35	3.36
4	112	165	664	"	103	21.35	.63	21.98	2.60	7.63	32.93	8.24
5	100	242	1066	"	134	21.00	.82	21.82	2.30	11.11	52.47	10.72
6	25	2974	1633	"	190	20.07	1.22	21.29	.56	133.22	78.43	15.20
7	100	76	135	Idle	—	8.50	.05	8.55	.76	1.15	2.18	—
8	25	2310	1196	2100	244	28.82	1.60	30.42	.80	147.85	82.08	19.52
9	75	359	885	"	179	30.02	1.13	31.15	2.47	23.53	62.19	14.32
10	75	152	464	"	104	30.40	.70	31.10	2.46	9.95	32.55	8.32
11	75	126	271	"	50	30.53	.45	30.98	2.45	8.21	18.94	4.00
12	112	114	156	"	—	30.58	.23	30.81	3.64	7.39	10.84	—
13	100	76	115	Idle	—	8.50	.05	8.55	.76	1.15	1.86	—
								TOTALS	25.16	364.38	392.13	83.68

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1					—							—
2					—							—
3												
4												
5												
6												
7					—							—
8												
9												
10												
11												
12					—							—
13					—							—
								TOTALS				

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	.30	
BSCO, g/bhp hr	4.35	
BSNO, g/bhp hr	4.69	

TABLE F-27. CUMMINS NH-250 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 15745/IHC
Source: Ryder Lease
Odom, Miles: 112,844
Date Tested: 11-12-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.08		29.10
Dry Bulb, °F	82		84
Wet Bulb, °F	74		75

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	87	114	86	Idle	———	8.50	.06	8.56	.66	1.72	1.39	———
2	100	152	86	1500	———	21.83	.22	22.05	2.33	7.05	4.28	———
3	67	165	326	"	64	21.63	.43	22.06	1.56	7.66	16.22	5.12
4	67	229	717	"	118	21.20	.72	21.92	1.55	10.56	35.46	9.44
5	50	452	1004	"	143	20.88	.88	21.76	1.15	20.69	49.29	11.44
6	12	3370	1423	"	194	19.95	1.25	21.20	.27	150.32	68.06	15.52
7	50	107	135	Idle	———	8.50	.06	8.56	.38	1.52	2.18	———
8	12	3255	1035	2100	251	29.53	1.68	30.31	.38	207.58	70.77	20.08
9	25	546	827	"	190	29.88	1.20	31.08	.82	35.70	57.99	15.20
10	25	229	536	"	134	30.28	.87	31.15	.82	15.01	37.67	10.72
11	50	165	271	"	65	30.50	.52	31.02	1.64	10.77	18.96	5.20
12	75	152	145	"	———	30.58	.30	30.88	.45	9.88	10.10	———
13	75	114	135	Idle	———	8.50	.06	8.56	.57	1.72	2.18	———
								TOTALS	14.59	480.18	374.55	92.72

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1					———							———
2					———							———
3												
4												
5												
6												
7					———							———
8												
9												
10												
11												
12					———							———
13					———							———
								TOTALS				

g/hr C_nH_{2n} = 0.0132 (ppm C_1H_x) (EXH. FLOW, lb/min) (Weight Factor)
g/hr CO = 0.0263 (ppm CO) (EXH. FLOW, lb/min) (Weight Factor)
g/hr NO = 0.0282 (ppm NO) (EXH. FLOW, lb/min) (Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.16	
BSCO, g/bhp hr	5.18	
BSNO, g/bhp hr	4.04	

TABLE F-28. CUMMINS NH-250 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 15746/IHC
Source: Ryder Lease
Odom, Miles: 101,749
Date Tested: 9-5-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.46	29.46	-
Dry Bulb, °F	75	75	77
Wet Bulb, °F	70	70	71

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	137	101	106	Idle	———	8.50	.06	8.56	1.07	1.52	1.71	———
2	125	126	96	1500	———	21.83	.20	22.03	2.91	5.84	4.77	———
3	87	152	337	"	59	21.67	.40	22.07	2.03	7.06	16.78	4.72
4	87	229	717	"	109	21.28	.67	21.95	2.02	10.58	35.51	8.72
5	75	492	1130	"	140	20.92	.85	21.77	1.72	22.54	55.50	11.20
6	25	3544	1405	"	195	19.92	1.27	21.19	.56	158.00	67.17	15.60
7	87	101	145	Idle	———	8.50	.06	8.56	.66	1.52	2.35	———
8	12	3142	1082	2100	254	28.50	1.70	30.20	.38	199.65	73.72	20.32
9	37	681	914	"	199	29.75	1.26	31.01	1.21	44.43	63.94	15.94
10	37	229	612	"	138	30.25	.88	31.13	1.22	15.00	42.98	11.04
11	50	165	326	"	65	30.50	.52	31.02	1.64	10.77	22.81	5.20
12	100	139	176	"	———	30.58	.29	30.87	3.26	9.03	12.26	———
13	87	101	166	Idle	———	8.50	.06	8.56	.66	1.52	2.68	———
								TOTALS	19.34	487.46	402.18	92.64

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1					———							———
2					———							———
3												
4												
5												
6												
7					———							———
8												
9												
10												
11												
12					———							———
13					———							———
								TOTALS				

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSH, g/bhp hr	0.21	
BSCO, g/bhp hr	5.26	
BSNO, g/bhp hr	4.34	

TABLE F-29. CUMMINS NH-250 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 24658K/Ford
Source: Ryder Lease
Odom, Miles: 19,168
Date Tested: 3-18-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.05	29.05	29.05
Dry Bulb, °F	91	93	92
Wet Bulb, °F	73	70	68

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	150	101	76	Idle	0	8.50	.05	8.55	1.13	1.52	1.23	0
2	175	126	96	1500	0	21.83	.13	21.96	4.06	5.82	4.76	0
3	125	126	303	"	34	21.75	.28	22.03	2.91	5.84	15.06	2.72
4	162	268	985	"	120	21.08	.73	21.81	3.73	12.30	43.55	9.60
5	98	1160	1264	"	166	20.50	1.03	21.53	2.00	52.55	61.39	13.28
6	38	2176	1423	"	198	19.83	1.30	21.13	.85	96.74	67.83	15.84
7	138	101	96	Idle	0	8.50	.05	8.55	1.04	1.52	1.55	0
8	25	1372	1066	2100	250	28.66	1.65	30.31	.80	98.77	72.99	20.00
9	100	439	785	"	180	30.00	1.13	31.13	3.29	28.75	55.13	14.40
10	100	216	524	"	120	30.33	.80	31.13	3.29	14.15	36.80	9.60
11	100	165	348	"	84	30.42	.61	31.03	3.28	10.77	24.36	6.72
12	250	178	125	"	0	30.58	.20	30.78	8.13	11.53	8.68	0
13	138	101	96	Idle	0	8.50	.05	8.55	1.04	1.52	1.55	0
								TOTALS	35.55	331.78	394.78	92.16

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	138	101	76	Idle	0	8.50	.05	8.55	1.04	1.52	1.23	0
2	188	114	96	1500	0	21.83	.13	21.96	4.36	5.27	4.76	0
3	138	101	314	"	52	21.67	.36	22.03	3.21	4.68	15.61	4.16
4	175	242	870	"	120	21.08	.73	21.81	4.03	11.11	42.81	9.60
5	100	1131	1247	"	162	20.58	1.00	21.58	2.28	51.35	60.71	12.96
6	38	2064	1405	"	196	19.91	1.26	21.17	.85	91.93	67.10	15.68
7	138	76	96	Idle	0	8.50	.05	8.55	1.04	1.15	1.55	0
8	38	1496	1082	2100	252	28.59	1.66	30.25	1.21	94.58	73.84	20.16
9	112	439	813	"	182	30.00	1.15	31.15	3.68	28.77	57.13	14.56
10	100	190	561	"	122	30.33	.81	31.14	3.29	12.45	39.41	9.76
11	100	139	359	"	82	30.42	.60	31.02	3.28	9.07	25.12	6.56
12	250	152	135	"	0	30.58	.20	30.78	8.13	9.84	9.37	0
13	138	76	96	Idle	0	8.50	.05	8.55	1.04	1.15	1.55	0
								TOTALS	37.44	322.87	400.19	93.44

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.38	0.40
BSCO, g/bhp hr	3.60	3.45
BSNO, g/bhp hr	4.28	4.28

TABLE F-30. CUMMINS NH-250 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 26353K/IHC
Source: Ryder Lease
Odom, Miles: 37,369
Date Tested: 4-17-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	28.96	28.96	29.95
Dry Bulb, °F	79	74	73
Wet Bulb, °F	77	70	70

RUN 1

MODE	C_1H_r, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	125	88	66	Idle	0	8.50	.06	8.56	.95	1.33	1.07	0
2	125	101	76	1500	0	21.24	.20	21.44	3.12	4.[illegible]	3.69	0
3	100	88	197	"	56	21.11	[illegible]	21.49	[illegible]	[illegible]	3.55	4.48
4	112	190	524	"	96	20.76	.60	21.36	[illegible]	7.54	25.25	7.68
5	138	[illegible]	1004	"	149	20.15	.92	21.07	[illegible]	[illegible]	47.7[illegible]	11.[illegible]
6	125	34[illegible]6	1351	"	204	18.93	1.35	20.28	[illegible].54	148.74	[illegible]	16.32
7	125	76	76	Idle	0	8.50	.05	8.55	0.95	1.15	1.22	0
8	[illegible]	[illegible]	974	2100	250	27.82	1.67	[illegible].49	[illegible]	197.91	64.80	[illegible]
9	[illegible]	425	612	"	179	28.98	1.13	[illegible].11	3.98	[illegible]	41.[illegible]	14.[illegible]
10	125	110	349	"	116	29.08	.77	[illegible]	[illegible]	11.[illegible]	[illegible]	9.28
11	112	126	197	"	54	29.39	.47	[illegible]	3.53	7.93	[illegible]	4.32
12	175	114	106	"	~~0~~	29.76	.20	29.96	5.54	7.19	7.16	0
13	150	76	76	Idle	0	8.50	.05	8.55	1.12	1.15	1.22	0
								TOTALS	24.[illegible]	410.31	302.52	[illegible]

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
								TOTALS				

g/hr C_nH_{2n} = 0.0132 (ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.39	
BSCO, g/bhp hr	4.65	
BSNO, g/bhp hr	3.43	

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TABLE F-31. CUMMINS NH-250 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 26354K/IHC
Source: Ryder Lease
Odom, Miles: 39,787
Date Tested: 4-17-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	28.96	28.95	28.93
Dry Bulb, °F	82	81	80
Wet Bulb, °F	77	79	79

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	150	101	66	Idle	0	8.50	.06	8.56	1.14	1.52	1.07	0
2	212	101	76	1500	0	20.87	.13	21.00	4.70	4.46	3.60	0
3	112	101	207	"	46	20.64	.33	20.97	2.48	4.46	9.79	3.68
4	162	216	561	"	100	20.43	.62	21.05	3.60	7.57	26.64	8.00
5	200	695	1051	"	146	20.13	.90	21.03	4.44	30.75	49.86	11.68
6	38	3142	1281	"	194	18.81	1.24	20.05	0.50	132.55	57.94	15.52
7	162	126	76	Idle	0	8.50	.05	8.55	1.23	1.90	1.23	0
8	25	2444	989	2100	246	27.03	1.62	28.65	0.76	147.33	63.92	19.68
9	262	465	638	"	184	28.15	1.17	29.32	8.11	28.69	42.20	[illegible]
10	175	242	359	"	120	28.51	.78	29.29	5.41	14.71	23.92	[illegible]
11	150	190	197	"	54	28.70	.47	29.17	4.62	11.66	12.96	5.32
12	325	203	106	"	0	28.98	.27	29.25	10.44	12.49	6.99	0
13	175	139	76	Idle	0	8.50	.05	8.55	1.31	2.01	1.23	0
								TOTALS	45.65	403.59	301.19	88.20

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	162	101	66	Idle	0	8.50	.06	8.56	1.23	1.52	1.07	0
2	200	101	76	1500	0	21.01	.13	21.14	4.46	4.49	3.62	0
3	100	88	207	"	48	20.92	.33	21.25	2.24	3.93	9.92	3.84
4	162	202	586	"	102	20.39	.63	21.02	3.60	8.98	27.79	8.16
5	175	722	1082	"	146	19.77	.90	20.67	3.92	31.40	50.46	11.68
6	25	3142	1218	"	196	18.44	1.27	19.71	0.52	130.30	57.72	15.68
7	150	76	76	Idle	0	8.50	.05	8.55	1.13	1.15	1.23	0
8	25	2376	1004	2100	248	27.02	1.63	28.65	0.76	143.22	64.89	19.84
9	250	396	638	"	187	28.12	1.18	29.30	7.74	23.90	42.17	14.96
10	150	178	359	"	121	28.70	.80	29.50	4.67	11.05	23.89	9.68
11	125	126	197	"	50	28.98	.45	29.43	3.88	7.80	13.08	4.00
12	325	126	115	"	0	29.02	.27	29.29	10.05	7.76	7.60	0
13	150	76	76	Idle	0	8.50	.05	8.55	1.13	1.15	1.23	0
								TOTALS	45.23	376.55	304.67	87.84

g/hr C_nH_{2n} = 0.0132 (ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.55	0.51
BSCO, g/bhp hr	4.56	4.29
BSNO, g/bhp hr	3.41	3.47

TABLE F-32. CUMMINS V-903 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 415/IHC
Source: ABC Lease
Odom, Miles: 75,515
Date Tested: 6-16-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.25	29.22	29.22
Dry Bulb, °F	92	104	93
Wet Bulb, °F	78	82	78

RUN 1 (left engine bank)

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	125	50	57	Idle	—	9.30	.06	9.36	1.03	.82	1.01	—
2	250	114	66	1800	—	29.17	.25	29.42	7.77	7.06	4.38	—
3	162	101	292	"	58	29.17	.44	29.61	5.07	6.39	19.51	4.64
4	150	114	625	"	122	29.17	.77	29.94	4.74	7.18	43.22	9.76
5	175	268	1147	"	188	28.52	1.17	29.69	5.49	16.74	76.83	15.04
6	62	4085	1593	"	249	28.17	1.67	29.84	1.95	256.47	107.24	19.92
7	125	50	76	Idle	—	9.30	.06	9.36	1.03	.82	1.38	—
8	62	2563	1316	2600	328	41.00	2.27	43.27	2.83	233.34	128.46	26.24
9	200	479	1035	"	232	41.25	1.53	42.78	9.04	43.11	99.89	18.56
10	150	.165	599	"	155	41.25	1.10	42.35	6.71	14.70	57.23	12.40
11	138	126	314	"	83	41.25	.75	42.00	6.12	11.13	27.75	6.64
12	200	139	135	"	—	41.25	.43	41.68	7.80	12.19	12.69	—
13	125	50	76	Idle	—	9.30	.06	9.36	1.03	.82	1.38	—
								TOTALS	61.61	610.67	581.97	113.20

RUN 2 (Right engine bank)

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	150	63	57	Idle	—	9.30	.06	9.36	1.24	1.34	1.01	—
2	250	126	66	1800	—	29.17	.25	29.42	7.77	7.80	4.38	—
3	162	114	292	"	64	29.17	.47	29.64	5.07	7.11	19.53	5.12
4	150	139	574	"	133	29.17	.83	30.00	4.75	8.77	38.85	10.64
5	162	399	1082	"	190	28.50	1.19	29.68	5.08	24.92	72.45	15.20
6	62	3603	1633	"	250	28.17	1.65	29.82	1.95	226.06	109.86	20.00
7	138	50	76	Idle	—	9.30	.06	9.36	1.14	.82	1.38	—
8	62	2580	1298	2600	335	41.00	2.33	43.33	2.84	235.21	126.88	26.80
9	162	613	1004	"	245	41.25	1.62	42.87	7.33	55.29	97.10	19.60
10	125	178	586	"	162	41.25	1.13	42.38	5.59	15.87	56.03	12.96
11	138	139	314	"	65	41.25	.67	41.92	6.11	12.26	27.70	5.20
12	200	139	135	"	—	41.25	.44	41.69	7.80	12.19	12.70	—
13	138	50	76	Idle	—	9.30	.06	9.36	1.14	.82	1.38	—
								TOTALS	58.81	609.16	571.25	115.52

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.54	0.51
BSCO, g/bhp hr	5.39	5.26
BSNO, g/bhp hr	5.14	4.95

TABLE F-33. CUMMINS V-903 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 966/White
Source: Brown Express
Odom, Miles: 41,027
Date Tested: 6-30-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.21	29.20	29.18
Dry Bulb, °F	95	96	95
Wet Bulb, °F	76	81	76

RUN 1

MODE	C_xH_y, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	175	101	47	Idle	—	9.30	.06	9.36	1.45	1.67	.83	—
2	775	216	47	1800	—	28.66	.23	28.89	22.64	13.13	3.06	—
3	375	152	135	"	50	28.66	.40	29.06	11.51	9.29	8.85	6.25
4	250	139	382	"	124	28.66	.68	29.34	7.75	8.58	25.29	9.92
5	350	355	[illegible]	"	188	28.52	1.17	29.69	10.97	15.93	61.22	15.04
6	187	2733	1554	"	244	28.18	1.60	29.78	5.88	172.50	104.46	[illegible]
7	150	96	66	Idle	—	9.30	.06	9.36	1.24	1.25	1.17	—
8	[illegible]	993	1130	2400	236	41.20	1.90	43.10	13.65	81.99	109.87	[illegible]
9	400	386	556	"	203	41.22	1.37	42.59	17.91	35.51	72.25	16.24
10	322	165	345	"	104	41.22	.85	42.07	14.44	14.61	33.03	8.32
11	425	178	176	"	56	41.22	.63	41.85	19.18	15.49	16.03	4.48
12	500	242	96	"	—	41.20	.33	41.53	35.08	21.15	7.12	—
13	150	96	57	Idle	—	9.30	.06	9.36	1.24	1.25	1.01	—
								TOTALS	162.63	[illegible]	454.72	[illegible]

RUN 2

MODE	C_xH_y, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	250	114	39	Idle	—	9.30	.06	9.36	2.07	1.88	.67	—
2	1125	255	47	1800	—	28.66	.37	29.03	34.37	15.53	3.07	—
3	500	190	145	"	50	28.66	.40	29.06	15.34	11.62	9.57	[illegible]
4	362	152	440	"	116	28.66	.73	29.39	11.24	9.40	29.17	9.28
5	475	294	1004	"	192	28.50	1.20	29.70	14.[illegible]	18.37	67.29	[illegible]
6	[illegible]	2753	1574	"	240	28.22	1.57	29.79	7.46	172.55	105.78	[illegible]
7	137	101	96	Idle	—	9.30	.06	9.36	1.55	1.67	1.34	—
8	325	993	1163	2400	282	41.20	1.98	43.18	17.06	89.55	113.03	23.56
9	512	344	956	"	192	41.22	1.30	42.52	22.99	35.70	92.11	15.36
10	400	190	349	"	[illegible]	41.22	.89	[illegible]	[illegible]	16.83	33.05	[illegible]
11	[illegible]	216	176	"	50	41.22	.60	41.82	22.11	19.01	16.60	4.00
12	[illegible]	255	[illegible]	"	—	41.20	.35	41.55	39.41	22.21	9.00	—
13	[illegible]	88	66	Idle	—	9.30	.06	9.36	1.86	1.45	1.17	—
								TOTALS	209.30	415.84	471.72	100.81

		RUN 1	RUN 2
g/hr C_nH_{2n} = 0.0132(ppm C_xH_y)(EXH. FLOW, lb/min)(Weight Factor)	BSHC, g/bhp hr	1.59	2.09
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)	BSCO, g/bhp hr	3.82	4.12
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)	BSNO, g/bhp hr	4.43	4.67

TABLE F-34. CUMMINS V-903 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 968/White
Source: Brown Express
Odom, Miles: 47,073
Date Tested: 8-11-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.11	29.11	29.16
Dry Bulb, °F	90	95	98
Wet Bulb, °F	78	77	80

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	595	139	38	Idle	——	9.30	.06	9.36	4.76	2.29	.67	——
2	2500	412	19	1800	——	28.66	.28	28.94	76.40	25.07	1.21	——
3	1675	255	76	"	62	28.66	.45	29.11	51.49	15.62	4.99	4.96
4	637	229	392	"	108	28.66	.70	29.36	19.75	14.15	25.30	8.64
5	1925	519	720	"	178	28.51	1.10	[illegible]	60.33	32.41	[illegible]	14.24
6	250	4085	1369	"	233	[illegible]	1.50	29.93	7.88	193.62	[illegible]	18.64
7	562	139	33	Idle	——	9.30	.06	9.36	4.65	2.29	.67	——
8	750	1219	956	2400	263	41.25	1.74	42.99	[illegible]	110.26	83.02	21.04
9	3000	654	536	"	191	41.25	1.30	42.55	99.87	59.55	51.45	[illegible]
10	975	373	249	"	122	41.25	.93	42.18	43.43	33.10	23.69	9.76
11	2500	386	76	"	53	41.25	.61	41.86	110.51	34.00	9.07	4.24
12	2500	439	38	"	——	41.25	.35	41.60	[illegible]	[illegible]	3.57	——
13	650	126	19	Idle	——	9.30	.06	9.36	5.38	2.08	.34	——
								TOTALS	619.32	561.88	345.02	96.80

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	575	165	47	Idle	——	9.30	.06	9.36	4.76	2.72	.99	——
2	2500	439	38	1800	——	28.66	.27	28.93	76.38	26.72	2.48	——
3	1625	281	105	"	58	28.66	.44	29.10	49.94	17.20	6.89	4.64
4	650	242	405	"	107	28.66	.69	29.35	20.15	14.94	26.82	8.56
5	1900	613	799	"	180	28.53	1.11	29.64	59.47	32.23	53.43	14.40
6	200	3142	1387	"	237	28.31	1.53	29.84	6.30	197.27	93.37	18.96
7	537	152	38	Idle	——	9.30	.06	9.36	4.45	2.51	.67	——
8	437	1292	914	2400	264	41.25	1.75	43.00	19.84	116.89	88.66	21.12
9	1962	709	549	"	196	41.25	1.31	42.56	88.18	63.49	52.71	15.68
10	925	359	260	"	122	41.25	.93	42.18	41.20	31.86	24.74	9.76
11	2500	412	115	"	53	41.25	.61	41.86	110.51	36.29	10.86	4.24
12	2500	439	47	"	——	41.25	.37	41.62	109.88	38.44	4.41	——
13	575	126	38	Idle	——	9.30	.06	9.36	4.76	2.08	.67	——
								TOTALS	595.82	588.64	366.54	97.36

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	6.39	6.12
BSCO, g/bhp hr	5.80	6.05
BSNO, g/bhp hr	3.56	3.76

TABLE F-35. CUMMINS V-903 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 970/White
Source: Brown Express
Odom, Miles: 43, 386
Date Tested: 8-10-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.11	29.19	29.15
Dry Bulb, °F	95	101	97
Wet Bulb, °F	77	79	79

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	425	114	38	Idle	—	9.30	.06	9.36	3.52	1.88	.67	—
2	2477	307	28	1800	—	28.66	.26	28.92	75.95	18.68	1.83	—
3	15[illegible]	229	105	"	56	28.66	.43	29.09	46.85	14.02	6.89	4.48
4	[illegible]	190	464	"	121	28.66	.75	29.41	18.43	11.76	42.[illegible]	9.68
5	[illegible]	281	771	"	66	28.58	1.03	29.61	28.14	17.51	51.50	13.28
6	300	2858	1633	"	236	28.31	1.52	29.83	11.03	179.31	109.90	18.88
7	[illegible]	89	57	Idle	—	9.30	.06	9.36	2.17	1.45	1.01	—
8	512	931	1114	2400	262	40.83	1.73	42.56	23.01	83.37	106.96	20.96
9	1112	359	703	"	186	40.83	1.26	42.09	49.43	31.79	66.75	14.88
10	750	555	382	"	118	40.83	.90	41.73	33.05	22.39	35.96	9.44
11	1600	307	197	"	62	40.83	.65	41.48	70.17	26.19	18.44	4.96
12	1937	394	66	"	—	40.83	.35	41.18	84.23	25.47	6.13	—
13	325	76	47	Idle	—	9.30	.06	9.36	[illegible]	1.25	.83	—
								TOTALS	449.68	435.73	434.73	96.56

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	400	126	38	Idle	—	9.30	.06	9.36	3.31	2.08	.67	—
2	2500	307	38	1800	—	28.66	.28	28.94	76.40	18.69	2.48	—
3	1250	229	135	"	55	28.66	.44	29.10	38.41	14.02	7.86	4.40
4	650	203	512	"	119	28.66	.75	29.41	17.08	12.56	33.97	9.52
5	962	281	758	"	172	28.58	1.06	29.64	26.98	17.55	50.69	13.76
6	300	3030	1633	"	235	28.33	1.50	29.83	9.45	190.17	109.90	18.80
7	312	101	57	Idle	—	9.30	.06	9.36	2.58	1.67	1.01	—
8	525	931	1130	2400	253	41.25	1.70	42.95	23.81	84.13	109.49	20.24
9	1137	412	758	"	190	41.25	1.29	42.54	51.08	36.89	72.75	15.20
10	750	268	416	"	116	41.25	.90	42.15	33.38	23.77	39.56	9.28
11	1500	320	207	"	58	41.25	.43	41.88	66.34	28.20	19.56	4.64
12	1900	307	76	"	—	41.25	.31	41.56	83.39	26.84	7.13	—
13	350	101	57	Idle	—	9.30	.06	9.36	2.90	1.67	1.01	—
								TOTALS	435.11	458.20	457.08	95.84

Formula		RUN 1	RUN 2
g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)	BSHC, g/bhp hr	4.65	4.54
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)	BSCO, g/bhp hr	4.51	4.78
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)	BSNO, g/bhp hr	4.66	4.77

TABLE F-36. CUMMINS V-903 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 972/White
Source: Brown Express
Odom, Miles: 40,833
Date Tested: 8-12-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.12	29.12	29.1
Dry Bulb, °F	96	98	95
Wet Bulb, °F	84	84	79

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	537	178	28	Idle	—	9.30	.06	9.36	4.45	2.94	.50	—
2	2500	492	19	1800	—	28.66	.27	29.93	76.38	29.95	1.24	—
3	1425	255	96	"	50	28.98	.40	29.38	44.21	15.76	6.36	4.00
4	487	229	382	"	120	29.00	.66	29.66	15.25	14.29	25.56	9.60
5	1375	546	744	"	170	28.91	1.05	29.57	42.94	33.97	41.63	13.60
6	237	3722	1441	"	226	28.83	1.45	30.29	7.58	231.13	78.41	18.08
7	500	178	38	Idle	—	9.30	.06	9.36	4.14	2.94	.47	—
8	500	1456	974	2400	264	41.93	1.74	42.57	22.48	130.41	73.54	21.12
9	2425	736	612	"	192	41.25	1.30	42.55	108.96	65.29	59.75	15.36
10	[illegible]	333	314	"	116	41.25	.89	42.14	35.60	29.52	29.35	9.28
11	1800	359	176	"	61	41.25	.70	41.95	79.74	31.69	16.66	[illegible]
12	2,500	546	47	"	—	41.25	.35	41.60	109.82	47.79	4.41	—
13	575	165	28	Idle	—	9.30	.06	9.36	4.76	2.72	.50	—
								TOTALS	556.31	645.00	[illegible]	[illegible]

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	500	178	47	Idle	—	9.30	.06	9.36	4.14	2.94	.83	—
2	2500	492	38	1800	—	28.65	.24	29.89	76.27	29.91	2.48	—
3	1400	255	135	"	53	28.66	.40	29.06	42.96	15.57	8.85	4.24
4	450	229	487	"	112	28.66	.70	29.36	13.95	14.15	32.26	8.96
5	1300	492	799	"	167	28.55	1.04	29.59	40.62	30.63	53.34	13.36
6	225	3603	1497	"	228	28.33	1.46	29.79	7.07	225.93	100.61	18.24
7	500	190	38	Idle	—	9.30	.06	9.36	4.14	3.13	.67	—
8	625	1336	1020	2400	254	41.25	1.68	42.93	28.33	120.67	99.79	20.32
9	2437	750	651	"	196	41.25	1.32	42.57	109.55	67.18	62.52	[illegible]
10	850	346	348	"	115	41.25	.70	42.15	37.83	30.68	33.09	9.20
11	1725	273	197	"	62	41.25	.70	41.95	76.12	32.92	18.74	4.96
12	2500	559	57	"	—	41.25	.35	41.60	109.82	48.93	5.35	—
13	575	178	38	Idle	—	9.30	.06	9.36	4.76	2.94	.67	—
								TOTALS	555.87	625.50	418.10	94.96

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	5.80	5.85
BSCO, g/bhp hr	6.72	6.59
BSNO, g/bhp hr	4.03	4.40

TABLE F-37. CUMMINS NTC-335 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 20/Kenworth
Source: Alamo Transportation
Odom, Miles: 65,013
Date Tested: 5-24-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.09	29.05	29.00
Dry Bulb, °F	85	89	94
Wet Bulb, °F	69	69	71

RUN 1

MODE	C,H$_x$, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C$_n$H$_{2n}$ (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	200	139	57	Idle	—	8.30	.15	8.35	1.48	2.05	.90	—
2	175	216	96	1500	—	20.66	.13	20.79	3.84	9.45	4.63	—
3	88	178	260	"	58	[illegible]	.46	22.29	2.07	8.35	13.07	4.44
4	113	255	813	"	116	[illegible]	.76	24.07	[illegible]	12.12	44.18	[illegible]
5	125	[illegible]	1369	"	168	[illegible]	1.06	[illegible]	3.46	41.38	80.98	[illegible]
6	113	1592	2063	"	[illegible]	38.16	1.49	[illegible]	3.54	99.31	[illegible]	[illegible]
7	188	152	96	Idle	—	[illegible]	.05	8.35	1.39	[illegible]	1.51	—
8	[illegible]	399	1369	2100	[illegible]	[illegible]	1.91	[illegible]	11.70	39.24	144.35	[illegible]
9	[illegible]	320	1114	"	14	[illegible]	1.46	[illegible]	10.00	26.10	100.43	[illegible]
10	[illegible]	255	717		[illegible]	34.50	1.10	[illegible]	5.64	19.10	57.58	[illegible]
11	[illegible]	[illegible]	282		[illegible]	[illegible]	.69	[illegible]	3.40	[illegible]	20.48	[illegible]
12	[illegible]	203	156		—	[illegible]	.36		4.07	13.18	10.56	—
13	[illegible]	152	96	Idle	—	[illegible]	.15	8.35	1.29	[illegible]	1.20	—
								TOTALS	54.75	298.46	[illegible]	[illegible]

RUN 2

MODE	C,H$_x$, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C$_n$H$_{2n}$ (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	12.5	152	66	Idle	—	8.30	.05	8.35	.92	2.24	1.04	—
2	150	203	96	1500	—	20.66	.13	20.79	3.29	8.88	4.50	—
3	62	190	282	"	54	[illegible]	.45	[illegible]	1.45	8.86	14.10	[illegible]
4	58	[illegible]	813	"	[illegible]	[illegible]	.79	[illegible]	2.22	13.47	43.82	[illegible]
5	100	[illegible]	1441	"	170	[illegible]	1.09	[illegible]	2.76	43.45	84.88	13.60
6	75	1577	2110	"	[illegible]	38.16	1.50	[illegible]	2.35	98.41	141.19	[illegible]
7	150	152	96	Idle	—	[illegible]	.05	8.35	1.11	2.24	1.51	—
8	[illegible]	465	1441	2100	58	[illegible]	1.93	[illegible]	11.84	46.07	153.09	[illegible]
9	[illegible]	346	1163	"	18	[illegible]	1.50	[illegible]	9.62	29.48	106.26	17.44
10	137	[illegible]	717	"	146	[illegible]	1.10	[illegible]	5.15	20.07	57.58	11.68
11	175	281	303	"	64	[illegible]	.65	[illegible]	5.90	18.89	21.84	[illegible]
12	137	203	176	"	—	[illegible]	.36	[illegible]	4.46	13.18	12.25	—
13	162	152	96	Idle	—	8.30	.15	8.35	1.20	2.24	1.51	—
								TOTALS	52.27	307.48	643.56	101.60

g/hr C$_n$H$_{2n}$ = 0.0132 (ppm C,H$_x$)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.50	0.50
BSCO, g/bhp hr	2.91	3.03
BSNO, g/bhp hr	6.01	6.33

TABLE F-38. CUMMINS NTC-335 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 144/Peterbilt
Source: Zero Refrigeration
Odom, Miles: 87,491
Date Tested: 5-6-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.09	-	29.12
Dry Bulb, °F	96	-	97
Wet Bulb, °F	74	-	76

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	200	114	96	Idle	—	8.30	.05	8.35	1.48	1.68	1.51	—
2	163	178	135	1500	—	[illegible]	[illegible]	21.03	3.62	7.88	6.40	—
3	88	114	337	"	62	21.66	.48	22.14	2.06	5.31	16.83	4.76
4	75	216	758	"	124	23.71	.81	24.52	1.94	11.14	41.93	7.92
5	63	1204	1734	"	190	25.90	1.21	27.11	1.80	68.68	106.05	[illegible]
6	75	1888	2436	"	254	[illegible]	1.70	30.96	2.45	122.98	170.14	20.32
7	175	63	145	Idle	—	8.30	.05	8.25	1.29	0.93	2.29	—
8	175	459	1776	2100	[illegible]	47.60	2.10	49.70	9.18	45.91	199.13	[illegible]
9	138	203	1333	"	232	40.30	1.58	41.88	6.10	17.89	125.94	18.56
10	113	114	677	"	128	33.70	1.00	34.70	4.14	9.32	53.00	10.24
11	100	114	405	"	73	31.66	.73	32.39	3.42	7.77	29.59	6.24
12	113	152	228	"	—	29.00	.43	29.43	3.51	9.41	15.14	—
13	200	88	125	Idle	—	8.30	.05	8.35	1.48	1.29	1.97	—
								TOTALS	43.47	309.19	763.12	110.40

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1					—							—
2					—							—
3												
4												
5												
6												
7					—							—
8												
9												
10												
11												
12					—							—
13					—							—
								TOTALS				

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.38	
BSCO, g/bhp hr	2.80	
BSNO, g/bhp hr	6.97	

TABLE F-39. CUMMINS NTC-335 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 458/Chev
Source: Howell Refining Co.
Odom, Miles: 126,772
Date Tested: 8-15-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.29	29.29	29.29
Dry Bulb, °F	92	100	102
Wet Bulb, °F	76	82	82

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	200	152	96	Idle	——	8.30	.05	8.35	1.49	2.24	1.20	——
2	150	126	96	1500	——	20.91	.20	21.11	3.34	5.60	4.57	——
3	88	74	326	"	66	22.00	.50	22.50	2.09	5.41	16.55	[illegible]
4	[illegible]	165	730	"	120	23.50	.90	[illegible]	[illegible]	9.44	40.62	9.60
5	133	576	[illegible]	"	188	26.00	1.20	27.20	3.59	23.54	103.99	15.04
6	100	1,747	2,463	"	250	29.50	1.66	31.16	3.29	114.53	173.07	20.00
7	[illegible]	114	123	Idle	——	8.30	.05	8.35	1.37	[illegible]	1.97	——
8	[illegible]	519	1,931	2100	334	49.50	2.19	[illegible]	12.29	56.43	214.41	[illegible]
9	200	216	1,349		242	40.66	1.63	42.29	8.93	[illegible]	130.61	19.36
10	138	126	774	"	140	34.16	1.06	35.22	5.13	9.34	59.12	11.20
11	[illegible]	101	337	"	[illegible]	32.16	.80	32.96	[illegible]	7.00	26.69	[illegible]
12	138	114	207	"	——	30.58	.38	30.96	4.51	7.43	14.46	——
13	188	114	135	Idle	——	8.30	.15	8.35	1.39	1.68	2.13	——
								TOTALS	52.47	272.53	[illegible]	113.76

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	175	152	86	Idle	——	8.30	.05	8.35	1.29	2.24	1.36	——
2	162	152	115	1500	——	21.00	.23	21.23	3.63	6.71	5.51	——
3	100	126	343	"	62	21.88	.48	22.36	2.36	5.93	17.55	4.96
4	100	178	744	"	126	23.66	.82	24.48	3.59	9.17	41.09	10.08
5	138	613	1,776	"	190	26.16	1.21	27.37	3.99	35.30	109.66	15.20
6	112	1,667	2,571	"	246	[illegible]	1.63	30.93	3.65	108.26	179.82	17.68
7	200	114	145	Idle	——	8.30	.05	8.35	1.48	1.68	2.29	——
8	250	519	1,927	2100	334	50.50	2.23	52.73	13.25	57.57	229.23	26.72
9	200	242	1,478	"	246	41.08	1.65	42.73	9.02	21.76	142.48	19.68
10	150	150	755	"	158	35.16	1.16	36.32	5.75	11.62	64.32	12.64
11	125	126	[illegible]	"	78	31.66	.72	[illegible]	4.28	8.51	27.91	6.24
12	150	101	207	"	——	30.66	.40	31.06	4.10	6.60	14.50	——
13	200	126	135	Idle	——	8.30	.05	8.35	1.48	2.21	2.13	——
								TOTALS	56.87	277.63	836.85	115.20

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.46	0.49
BSCO, g/bhp hr	2.40	2.41
BSNO, g/bhp hr	6.93	7.26

TABLE F-40. CUMMINS NTC-335 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 6213/IHC
Source: Southern Pacific
Odom, Miles: 114,382
Date Tested: 9-15-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.08	29.09	29.10
Dry Bulb, °F	91	92	94
Wet Bulb, °F	73	73	74

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	175	114	86	Idle	—	8.50	.06	8.56	1.32	1.72	1.39	—
2	150	203	115	1500	—	20.70	.17	20.87	3.31	8.91	5.41	—
3	100	178	292	"	46	21.55	.41	21.96	2.32	8.22	14.47	3.69
4	112	242	885	"	118	23.42	.78	24.20	2.86	12.32	49.[illegible]	9.44
5	125	861	1,460	"	176	25.50	1.12	26.62	3.51	49.22	87.68	14.09
6	125	1,532	2,206	"	234	28.67	1.56	30.23	3.19	97.44	150.45	15.98
7	175	152	115	Idle	—	8.50	.06	8.56	1.32	2.29	1.86	—
8	212	425	1,298	2100	292	45.50	1.95	47.45	10.62	42.43	139.15	22.36
9	225	268	1,179	"	218	39.00	1.50	40.50	9.62	22.84	107.72	17.44
10	175	268	664	"	144	34.33	1.09	35.41	4.54	15.97	53.04	11.52
11	88	333	303	"	74	31.67	.72	32.39	2.01	22.69	22.14	5.92
12	100	255	135	"	—	30.55	.39	30.94	3.27	16.60	9.42	—
13	188	152	106	Idle	—	8.50	.06	8.56	1.42	2.29	1.71	—
								TOTALS	53.11	305.94	649.5[illegible]	104.3[illegible]

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	125	126	106	Idle	—	8.50	.06	8.56	0.95	1.70	1.71	—
2	125	216	135	1500	—	20.70	.16	20.86	2.75	9.48	6.35	—
3	75	203	326	"	45	21.50	.40	21.90	1.73	9.35	16.11	3.60
4	88	255	921	"	116	23.33	.77	24.10	2.24	12.72	50.51	9.28
5	125	819	1,516	"	171	25.33	1.09	26.42	3.49	45.53	90.36	13.68
6	138	1,592	2,306	"	235	28.50	1.55	30.05	4.38	100.65	156.33	18.80
7	150	178	135	Idle	—	8.50	.06	8.56	1.14	2.68	2.18	—
8	200	412	1,405	2100	296	44.92	1.72	46.64	9.89	40.60	148.47	22.88
9	225	307	1,230	"	216	38.67	1.48	40.15	9.54	25.93	111.41	17.28
10	162	255	717	"	140	34.17	1.07	35.24	6.03	18.91	57.00	11.20
11	62	307	348	"	70	31.50	.69	32.19	2.11	20.79	25.27	5.60
12	75	242	152	"	—	30.58	.38	30.96	2.45	15.76	10.62	—
13	150	178	135	Idle	—	8.50	.06	8.56	1.14	2.68	2.18	—
								TOTALS	47.84	307.19	678.50	102.32

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	0.50	0.48
BSCO, g/bhp hr	2.93	3.00
BSNO, g/bhp hr	6.16	6.63

TABLE F-41. MACK ENDT 675 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 1/Mack
Source: Fernandez Bros. Produce
Odom, Miles: 109,851
Date Tested: 5-28-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	28.97	28.98	28.94
Dry Bulb, °F	92	94	96
Wet Bulb, °F	79	79	81

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	488	412	271	Idle	———	6.66	.03	6.69	2.89	4.86	3.42	———
2	750	333	228	1260	———	15.17	.11	15.28	12.10	10.71	7.86	———
3	675	139	944	"	53	15.91	.36	16.27	11.60	4.76	34.65	4.24
4	688	101	1298	"	82	17.85	.50	18.35	13.33	2.90	53.73	6.56
5	488	791	2256	"	146	21.46	.83	22.29	11.49	27.10	113.45	11.68
6	88	1856	2206	"	202	25.44	1.18	26.62	2.47	103.95	132.48	16.16
7	450	281	416	Idle	———	6.66	.03	6.69	2.66	2.31	5.26	———
8	150	681	1230	2100	234	42.03	1.53	43.56	6.90	62.41	120.87	18.72
9	238	847	974	"	178	39.04	1.18	40.22	10.11	71.68	88.38	14.24
10	500	709	561	"	124	34.87	.90	35.77	18.89	53.36	45.27	9.92
11	775	439	348	"	60	30.41	.61	31.02	25.39	28.65	24.35	4.80
12	988	307	197	"	———	27.76	.35	28.11	29.33	18.16	12.49	———
13	462	386	314	Idle	———	6.66	.03	6.69	2.73	4.55	3.97	———
								TOTALS	149.89	[illegible]	646.19	86.41

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	475	373	314	Idle	———	6.66	.03	6.69	2.81	4.40	3.97	———
2	725	307	249	1260	———	15.17	.13	15.30	11.71	9.88	8.59	———
3	625	114	1020	"	53	15.91	.36	16.27	10.74	3.90	37.44	4.24
4	675	165	1818	"	100	17.85	.60	18.45	13.15	6.41	75.67	8.00
5	412	1103	2409	"	154	21.46	.88	22.34	9.72	51.84	121.41	12.32
6	75	1920	2256	"	206	25.44	1.21	26.65	2.11	107.66	135.64	16.48
7	438	242	440	Idle	———	6.66	.03	6.69	2.59	2.85	5.56	———
8	150	627	1247	2100	234	42.03	1.53	43.56	6.90	57.46	122.54	18.72
9	225	805	1004	"	178	39.04	1.18	40.22	9.56	68.12	91.10	14.24
10	500	681	574	"	124	34.87	.90	35.77	18.89	51.25	46.32	9.92
11	788	386	348	"	60	30.41	.61	31.02	25.81	25.19	24.35	4.80
12	1038	268	197	"	———	27.76	.35	28.11	30.81	15.85	12.49	———
13	475	359	326	Idle	———	6.66	.03	6.69	2.81	4.23	4.12	———
								TOTALS	147.61	409.04	689.20	88.72

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.73	1.66
BSCO, g/bhp hr	4.71	4.61
BSNO, g/bhp hr	7.48	7.77

TABLE F-42. MACK ENDT 675 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 5/Mack
Source: Fernandez Bros. Produce
Odom, Miles: 113,283
Date Tested: 5-25-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.15	29.14	29.1
Dry Bulb, °F	88	94	96
Wet Bulb, °F	74	75	75

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	425	492	282	Idle	—	6.66	.04	6.70	2.52	5.91	3.57	—
2	537	307	292	1260	—	15.17	.15	15.32	8.69	7.90	9.75	—
3	550	152	941	"	42	15.91	.31	16.22	9.42	5.19	[illegible]	3.36
4	612	126	1554	"	96	17.85	.57	18.42	11.90	4.88	64.50	7.68
5	400	861	2357	"	146	21.46	.82	22.29	7.42	40.39	118.52	11.68
6	137	1608	2462	"	178	25.44	1.15	26.59	3.85	89.96	147.61	14.24
7	387	294	536	Idle	—	6.66	.04	6.70	2.57	3.47	6.79	—
8	175	819	1281	2100	232	42.03	1.50	43.53	7.04	75.01	105.36	18.56
9	275	875	944	"	164	39.04	1.11	40.15	11.66	73.18	95.51	[illegible]
10	400	.681	717	"	124	34.87	.90	35.77	15.11	51.25	57.96	[illegible]
11	625	386	348	"	54	30.41	.60	31.01	20.47	33.18	24.35	4.32
12	725	126	115	"	—	27.76	.36	28.12	21.52	9.45	7.20	—
13	400	412	370	Idle	—	6.66	.03	6.69	2.37	4.86	4.68	—
								TOTALS	[illegible]	[illegible]	666.93	82.88

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	425	505	348	Idle	—	6.66	.03	[illegible]	2.51	[illegible]	4.40	—
2	562	359	303	1360	—	15.17	.15	[illegible]	[illegible]	11.57	10.47	—
3	575	178	989	"	46	15.91	.34	[illegible]	9.87	6.09	34.26	3.48
4	625	152	1693	"	96	17.85	.57	[illegible]	12.16	5.89	70.35	7.68
5	425	875	2571	"	144	21.46	.82	22.28	10.00	41.02	129.23	11.52
6	137	1731	2627	"	176	25.44	1.16	[illegible]	3.85	96.83	157.65	14.08
7	375	307	596	Idle	—	6.66	.03	6.69	[illegible]	3.42	7.41	—
8	150	819	1333	2100	234	42.03	1.52	43.55	6.90	78.04	130.97	18.72
9	250	917	1004	"	170	39.04	1.13	40.17	10.60	77.50	90.99	13.60
10	400	695	730	"	116	34.87	.97	35.74	15.10	[illegible]	59.86	9.28
11	600	399	370	"	54	30.41	.60	31.01	19.65	26.03	25.88	4.32
12	700	[illegible]	239	"	—	27.76	.36	28.12	20.79	15.09	15.16	—
13	400	439	370	Idle	—	6.66	.03	6.69	2.37	5.18	4.68	—
								TOTALS	125.11	423.12	742.31	82.88

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.54	1.51
BSCO, g/bhp hr	[illegible]	5.09
BSNO, g/bhp hr	[illegible]	8.96

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TABLE F-43. MACK ENDT 673B 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 060122/Mack
Source: Post Office Dept.
Odom, Miles: 10,490
Date Tested: 3-16-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.08	29.06	29.05
Dry Bulb, °F	96	101	97
Wet Bulb, °F	71	72	71

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	450	268	282	Idle	—0—	7.10	.03	7.13	2.84	3.37	3.80	—0—
2	925	399	282	1600	—0—	15.33	.18	15.51	15.15	13.02	9.87	—0—
3	875	216	799	1600	55	18.33	.40	18.73	17.31	8.51	33.76	4.40
4	[illegible]	139	1247	1600	96	20.59	.61	21.19	20.99	6.20	59.61	7.69
5	[illegible]	[illegible]	[illegible]	1600	145	23.16	.88	24.04	18.74	18.16	89.56	11.60
6	[illegible]	1426	1921	1600	[illegible]	25.33	1.08	26.41	10.82	79.24	110.89	14.64
7	400	203	359	Idle	—0—	7.10	.03	7.13	2.52	2.55	4.84	—0—
8	375	960	1478	1900	[illegible]	31.16	1.20	32.36	12.81	65.36	107.90	15.84
9	612	373	1516	1900	[illegible]	29.16	1.03	30.19	19.51	23.69	103.25	13.28
10	788	152	1114	1900	[illegible]	25.16	.66	25.82	21.49	8.26	64.89	7.68
11	850	216	771	1900	[illegible]	22.58	.43	23.01	20.65	10.46	40.02	4.16
12	950	333	382	1900	—0—	19.50	.23	19.73	19.79	13.82	17.00	—0—
13	470	216	348	Idle	—0—	7.10	.05	7.15	3.00	2.72	4.70	—0—
								TOTALS	183.62	255.36	649.08	79.28

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	450	307	282	Idle	—0—	7.10	.03	7.13	2.84	3.86	3.80	—0—
2	925	479	292	1600	—0—	15.33	.18	15.51	15.15	15.63	10.22	—0—
3	875	255	813	1600	55	18.33	.40	18.73	17.31	10.05	34.35	4.40
4	950	178	1264	1600	99	20.66	.63	21.29	21.36	7.97	60.71	7.92
5	750	399	[illegible]	1600	145	23.16	.88	24.04	19.04	20.18	89.65	11.60
6	400	[illegible]	1818	1600	193	25.83	1.13	26.96	11.39	80.89	110.57	15.40
7	400	242	348	Idle	—0—	7.10	.03	7.13	2.52	3.04	4.69	—0—
8	362	1045	1554	1900	216	32.08	1.30	33.38	12.76	73.39	117.02	17.28
9	612	396	1516	1900	[illegible]	28.75	.98	29.73	19.21	24.15	101.68	12.64
10	788	[illegible]	1114	1900	116	26.33	.76	27.09	22.54	10.15	68.08	9.28
11	850	242	785	1900	[illegible]	22.58	.43	23.01	20.65	11.72	40.75	4.16
12	925	373	393	1900	—0—	19.50	.23	19.73	19.27	15.48	17.49	—0—
13	450	242	359	Idle	—0—	7.10	.03	7.13	2.84	3.04	4.84	—0—
								TOTALS	186.88	279.55	663.85	82.68

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	2.32	2.26
BSCO, g/bhp hr	3.22	3.38
BSNO, g/bhp hr	8.19	8.03

TABLE F-44. MACK ENDT 673B 13 MODE GASEOUS EMISSIONS SUMMARY

		Inlet Conditions	Before	Between	After
Vehicle No/Make:	060124/Mack	Bar, in Hg Corr	29.06	29.05	29.09
Source:	Post Office Dept.	Dry Bulb, °F	86	87	87
Odom, Miles:	8,986	Wet Bulb, °F	69	66	70
Date Tested:	3-17-71				

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	512	532	271	Idle	0	7.10	.03	7.13	3.23	6.68	3.65	0
2	925	572	337	1600	0	15.33	.18	15.51	15.15	18.67	11.79	0
3	888	229	1114	1600	61	18.66	.45	19.11	17.92	9.21	48.03	4.88
4	912	203	1633	1600	101	20.83	.65	21.48	20.69	9.17	79.13	8.08
5	812	399	2040	1600	149	23.50	.90	24.40	20.92	20.48	112.29	11.92
6	475	1547	2158	1600	205	26.41	1.21	27.62	13.85	89.90	134.47	16.40
7	475	439	370	Idle	0	7.10	.03	7.13	3.00	5.52	4.98	0
8	462	1016	2306	1900	236	33.25	1.40	34.65	16.90	74.07	180.26	18.88
9	675	425	2332	1900	178	29.91	1.11	31.02	22.11	27.74	163.20	14.24
10	875	203	1904	1900	131	27.16	.85	28.01	25.88	11.96	120.31	10.48
11	812	229	1163	1900	74	23.83	.50	24.33	20.86	11.72	63.84	5.92
12	912	425	464	1900	0	19.50	.28	19.78	19.05	17.67	20.71	0
13	525	439	359	Idle	0	7.10	.03	7.13	3.31	5.52	4.84	0
								TOTALS	202.87	308.33	947.50	90.80

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	562	559	249	Idle	0	7.10	.03	7.13	3.54	7.02	3.35	0
2	1000	572	337	1600	0	15.33	.20	15.53	16.40	18.69	11.81	0
3	938	203	1179	1600	61	18.66	.45	19.11	18.93	8.16	50.83	4.88
4	912	165	1734	1600	105	21.08	.66	21.74	20.94	7.55	85.04	8.40
5	788	333	2086	1600	138	22.91	.88	23.79	19.80	16.67	111.96	11.00
6	462	1426	2281	1600	205	26.41	1.20	27.61	13.47	92.84	142.08	16.40
7	475	373	393	Idle	0	7.10	.03	7.13	3.00	4.69	5.29	0
8	475	903	2306	1900	236	33.25	1.40	34.65	17.38	65.83	180.26	18.88
9	688	333	2306	1900	178	29.91	1.11	31.02	22.54	21.73	161.38	14.24
10	838	152	1883	1900	134	27.33	.86	28.19	24.95	9.02	119.75	10.72
11	825	190	1163	1900	74	23.83	.50	24.33	21.20	9.73	63.84	5.92
12	938	373	464	1900	0	19.50	.26	19.76	19.57	15.51	20.68	0
13	512	399	348	Idle	0	7.10	.03	7.13	3.23	5.01	4.69	0
								TOTALS	204.95	272.45	960.96	90.44

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)

g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)

g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	2.23	2.27
BSCO, g/bhp hr	3.40	3.01
BSNO, g/bhp hr	10.44	10.63

TABLE F-45. CATERPILLAR 1145 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 507/Ford
Source: Coca Cola
Odom, Miles: 7,222
Date Tested: 2-13-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.30	29.30	29.29
Dry Bulb, °F	68	71	73
Wet Bulb, °F	54	56	59

RUN 1

MODE	C,Hx, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	375	281	197	IDLE	—0—	4.83	.05	4.88	1.62	2.42	1.82	—0—
2	638	333	197	1920	—0—	17.38	.15	17.53	11.81	12.28	7.79	—0—
3	550	307	536	"	33	17.24	.28	17.52	10.18	11.32	21.19	2.64
4	775	2.03	885	"	61	16.93	.44	17.37	14.22	7.42	34.68	4.88
5	775	386	1298	"	89	16.65	.61	17.26	14.13	14.02	50.54	7.12
6	550	2410	1441	"	115	16.42	.78	17.20	9.79	87.22	55.92	9.20
7	325	203	2.60	IDLE	—0—	4.74	.05	4.79	1.38	1.71	2.35	—0—
8	450	1516	1230	3200	159	27.12	1.09	28.81	13.69	91.89	79.94	12.72
9	800	333	1020	"	122	28.01	.86	28.87	24.39	20.23	66.43	9.76
10	775	2.81	744	"	85	28.14	.67	28.81	23.58	17.03	48.36	6.80
11	500	320	425	"	39	27.95	.44	28.37	14.99	19.11	25.94	3.12
12	625	357	207	"	—0—	17.22	.30	17.52	11.56	13.23	8.18	—0—
13	300	2.55	218	IDLE	—0—	4.77	.05	4.82	1.28	2.17	1.99	—0—
								TOTALS	152.82	300.05	405.13	56.24

RUN 2

MODE	C,Hx, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	325	2.81	218	IDLE	—0—	4.83	.05	4.88	1.40	2.42	2.01	—0—
2	600	359	207	1920	—0—	17.50	.15	17.65	11.18	12.33	8.24	—0—
3	500	307	536	"	33	17.33	.28	17.61	9.30	11.37	21.29	2.64
4	738	2.16	914	"	61	16.93	.44	17.37	13.54	7.89	35.82	4.88
5	662	492	1351	"	91	16.82	.63	17.45	12.20	18.06	53.19	7.28
6	550	2648	1478	"	112	16.34	.76	17.10	9.93	95.27	57.02	8.96
7	275	2.16	2.82	IDLE	—0—	4.76	.05	4.81	1.17	1.83	2.56	—0—
8	375	1794	1264	3200	163	27.19	1.11	28.30	11.21	106.82	80.70	13.04
9	762	333	1066	"	119	27.43	.85	28.28	22.76	19.81	68.01	9.52
10	775	2.68	799	"	81	27.44	.65	28.09	22.99	15.84	50.63	6.48
11	475	320	416	"	39	27.39	.44	27.83	13.96	18.74	26.12	3.12
12	600	386	218	"	—0—	17.22	.30	17.52	11.10	14.23	8.62	—0—
13	262	2.29	2.39	IDLE	—0—	4.33	.05	4.38	1.01	1.77	1.98	—0—
								TOTALS	141.75	327.38	416.19	55.92

g/hr C_nH_{2n} = 0.0132(ppm C,Hx)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	2.72	2.53
BSCO, g/bhp hr	5.33	5.85
BSNO, g/bhp hr	7.20	7.44

TABLE F-46. CATERPILLAR 1145 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 510/Ford
Source: Coca Cola
Odom, Miles: 6,222
Date Tested: 2-12-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.52	29.52	29.54
Dry Bulb, °F	68	66	65
Wet Bulb, °F	48	47	47

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	475	386	239	Idle	—0—	4.83	.05	4.88	2.05	3.32	2.20	—0—
2	700	425	228	1920	—0—	17.53	.13	17.66	13.05	15.79	9.08	—0—
3	625	346	651	"	29	17.33	.28	17.61	11.62	12.82	25.76	2.32
4	662	268	1004	"	51	17.17	.38	17.55	15.98	9.90	39.75	4.07
5	850	640	1575	"	84	17.00	.58	17.58	15.78	23.67	60.98	6.72
6	688	3370	1693	"	106	16.83	.72	17.55	12.75	124.44	67.03	8.48
7	350	346	326	Idle	—0—	4.83	.05	4.88	1.51	2.98	3.01	—0—
8	900	681	1264	3200	148	27.74	1.02	28.76	27.33	41.21	82.01	11.84
9	900	386	1020	"	109	27.69	.80	28.49	27.08	23.14	65.56	8.72
10	750	373	744	"	70	27.57	.60	28.17	22.31	22.11	47.22	5.60
11	600	399	475	"	44	27.83	.47	28.30	17.93	23.76	33.33	3.52
12	712	412	239	"	—0—	17.41	.33	17.74	13.34	15.38	9.57	—0—
13	375	333	292	Idle	—0—	4.83	.05	4.88	1.62	2.86	2.69	—0—
								TOTALS	182.35	321.38	448.25	51.28

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	400	386	239	Idle	—0—	4.83	.05	4.88	1.73	3.32	2.20	—0—
2	612	425	218	1920	—0—	17.50	.15	17.65	11.41	15.43	8.68	—0—
3	550	333	638	"	29	17.33	.28	17.61	10.23	12.34	25.35	2.32
4	800	255	1035	"	54	17.17	.40	17.57	14.84	9.42	41.03	4.32
5	788	546	1516	"	88	16.92	.55	17.47	14.54	20.07	59.75	7.04
6	650	3312	1693	"	103	16.83	.70	17.53	12.03	122.16	66.95	8.24
7	350	301	314	Idle	—0—	4.83	.05	4.88	1.51	2.64	2.90	—0—
8	888	709	1247	3200	142	28.25	.98	29.23	27.41	43.60	82.23	11.36
9	938	386	1035	"	112	28.17	.82	28.99	28.72	23.54	67.69	8.96
10	725	346	730	"	67	28.25	.58	28.83	22.07	20.99	47.48	5.36
11	562	399	440	"	44	28.25	.47	28.72	17.04	24.11	28.51	3.52
12	625	412	228	"	—0—	17.42	.33	17.75	11.72	15.39	9.13	—0—
13	325	320	271	Idle	—0—	4.83	.05	4.88	1.40	2.75	2.50	—0—
								TOTALS	174.65	315.76	444.40	51.12

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	3.55	3.41
BSCO, g/bhp hr	6.26	6.17
BSNO, g/bhp hr	8.74	8.69

TABLE F-47. CATERPILLAR 1145 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 512/Ford
Source: Coca Cola
Odom, Miles: 3,438
Date Tested: 2-19-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.05	29.05	29.05
Dry Bulb, °F	77	75	69
Wet Bulb, °F	57	56	53

RUN 1

MODE	C,H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	388	333	260	Idle	0	4.83	.03	4.86	1.67	2.85	2.39	0
2	650	294	218	1920	0	17.43	.12	17.55	12.05	10.86	8.63	0
3	625	281	612	"	30	17.33	.27	17.60	11.62	10.41	24.30	2.40
4	825	190	1066	"	61	17.12	.45	17.57	15.31	7.02	42.25	4.88
5	850	437	1460	"	86	16.89	.60	17.49	15.70	16.15	57.61	6.88
6	650	2717	1593	"	117	16.54	.78	17.32	11.89	106.37	62.24	9.36
7	400	376	348	Idle	0	4.74	.03	4.77	1.69	3.24	3.14	0
8	700	1045	1264	3200	161	21.12	1.10	22.22	16.43	48.85	63.36	12.88
9	812	307	1020	"	122	27.62	.97	28.49	24.43	18.40	65.56	9.76
10	550	268	717	"	80	27.70	.65	28.35	16.47	15.99	45.86	6.40
11	492	307	464	"	47	28.25	.48	28.73	14.81	18.56	30.07	3.76
12	625	346	239	"	0	28.21	.35	28.56	18.85	20.79	15.40	0
13	375	333	303	Idle	0	4.74	.03	4.77	1.58	2.80	2.43	0
								TOTALS	162.50	282.29	422.54	56.32

RUN 2

MODE	C,H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	375	359	247	Idle	0	4.83	.03	4.86	1.61	3.07	2.29	0
2	625	294	218	1920	0	17.50	.11	17.61	11.62	10.89	8.66	0
3	475	255	638	"	32	17.33	.26	17.59	8.82	9.44	25.32	2.56
4	725	178	1066	"	62	16.94	.45	17.39	13.31	6.51	41.82	4.96
5	725	492	1441	"	92	16.91	.60	17.51	13.41	18.13	56.92	7.36
6	500	3086	1554	"	114	16.75	.78	17.53	9.26	113.82	61.46	9.12
7	362	412	337	Idle	0	4.83	.03	4.86	1.56	3.53	3.09	0
8	650	1045	1213	3200	165	28.21	1.10	29.31	20.12	64.44	80.21	13.20
9	700	307	959	"	125	28.16	.86	29.02	21.45	19.74	62.78	10.00
10	550	291	677	"	83	28.21	.65	28.86	16.76	17.06	44.08	6.64
11	525	320	440	"	47	17.23	.48	17.71	9.82	11.92	17.58	3.76
12	650	359	218	"	0	17.46	.35	17.81	12.22	13.42	8.76	0
13	362	291	249	Idle	0	4.83	.03	4.86	1.56	2.41	2.29	0
								TOTALS	141.52	294.38	415.26	57.60

g/hr C_nH_{2n} = 0.0132(ppm-C,H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm-CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm-NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	2.88	2.45
BSCO, g/bhp hr	5.01	5.09
BSNO, g/bhp hr	7.52	7.25

TABLE F-48. CATERPILLAR 1145 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 519/Ford
Source: Coca Cola
Odom, Miles: 17,033
Date Tested: 2-26-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.07	29.07	29.08
Dry Bulb, °F	78	77	81
Wet Bulb, °F	64	56	62

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	250	268	176	Idle	—0—	4.83	.03	4.86	1.07	2.30	1.62	—0—
2	400	307	166	1920	—0—	17.50	.13	17.63	7.45	11.39	6.60	—0—
3	562	346	382	"	28	17.22	.25	17.58	10.43	12.80	15.15	2.24
4	700	229	771	"	54	17.17	.40	17.57	12.99	8.47	30.56	4.32
5	825	281	1082	"	76	17.00	.53	17.53	15.27	10.36	42.79	6.08
6	625	2277	1333	"	111	16.41	.75	17.16	11.33	82.21	51.60	8.88
7	288	229	260	Idle	—0—	4.70	.03	4.73	1.20	1.91	2.32	—0—
8	675	627	929	3200	139	27.41	.96	28.37	20.22	37.43	59.46	11.12
9	575	333	744	"	103	28.16	.76	28.92	17.56	20.26	48.54	8.24
10	450	307	549	"	70	27.48	.60	28.08	13.34	18.14	34.78	5.60
11	475	346	303	"	37	27.67	.43	28.10	14.10	20.46	19.21	2.96
12	575	386	176	"	—0—	27.94	.33	28.27	17.17	22.96	11.22	—0—
13	350	281	218	Idle	—0—	4.75	.03	4.78	1.48	2.37	1.97	—0—
								TOTALS	143.61	251.06	325.82	49.44

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	250	281	186	Idle	—0—	4.83	.03	4.86	1.07	2.41	1.71	—0—
2	425	333	176	1920	—0—	17.50	.13	17.63	7.91	12.35	7.00	—0—
3	600	359	370	"	24	17.47	.23	17.70	11.21	13.37	14.77	1.92
4	650	242	758	"	54	17.17	.40	17.57	12.06	8.95	30.05	4.32
5	800	281	1066	"	76	17.00	.53	17.53	14.81	10.36	42.16	6.08
6	625	2145	1316	"	109	16.83	.73	17.56	11.57	79.25	52.13	8.72
7	300	255	260	Idle	—0—	4.73	.03	4.76	1.26	2.14	2.34	—0—
8	750	640	914	3200	142	27.69	.98	28.67	22.71	38.61	59.12	11.36
9	575	333	703	"	99	28.12	.75	28.87	17.53	20.23	45.79	7.92
10	475	320	536	"	70	28.19	.60	28.79	14.44	19.38	34.81	5.60
11	488	386	303	"	37	28.21	.43	28.64	14.76	23.26	19.58	2.96
12	612	425	176	"	—0—	28.25	.33	28.58	18.47	25.56	11.35	—0—
13	288	255	197	Idle	—0—	4.83	.03	4.86	1.24	2.18	1.81	—0—
								TOTALS	149.06	258.05	322.62	48.88

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	2.90	3.05
BSCO, g/bhp hr	5.08	5.27
BSNO, g/bhp hr	6.59	6.60

TABLE F-49. CATERPILLAR 1145 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 527/Ford
Source: Coca Cola
Odom, Miles: 4,006
Date Tested: 2-20-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.07	29.05	29.05
Dry Bulb, °F	74	76	78
Wet Bulb, °F	65	65	67

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	550	377	218	Idle	0	4.83	.03	4.86	2.36	3.42	2.00	0
2	650	425	186	1920	0	17.53	.13	17.66	12.12	15.79	7.41	0
3	700	307	547	"	33	17.33	.28	17.61	12.02	11.37	21.91	2.64
4	1000	242	[illegible]	"	54	17.17	.40	17.57	17.55	7.15	33.34	[illegible]
5	[illegible]	171	[illegible]	"	[illegible]	16.92	.57	17.49	[illegible]	[illegible]	45.89	[illegible]
6	750	3486	[illegible]	"	103	16.80	.90	17.70	13.86	193.35	51.25	8.24
7	512	386	303	Idle	0	4.74	.03	4.77	2.16	3.24	2.73	0
8	725	1376	[illegible]	3200	145	28.07	1.00	29.07	[illegible]	[illegible]	79.55	11.60
9	1100	477	1035	"	106	[illegible]	.79	[illegible]	33.11	[illegible]	66.55	8.49
10	900	[illegible]	735	"	72	28.16	.62	28.78	[illegible]	[illegible]	50.97	5.76
11	575	412	440	"	33	28.15	.42	28.57	17.35	[illegible]	28.36	2.64
12	725	465	197	"	0	17.56	.28	17.84	12.66	17.45	7.93	0
13	525	396	239	Idle	0	4.79	.03	4.81	[illegible]	3.29	2.17	0
								TOTALS	[illegible]	375.93	399.96	51.16

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	512	[illegible]	[illegible]	Idle	0	483	.05	4.88	2.21	3.54	2.01	0
2	625	452	176	1920	0	17.53	.13	17.66	11.66	16.79	7.01	0
3	638	307	574	"	33	17.33	.28	17.61	11.86	11.39	22.30	2.64
4	900	229	929	"	54	17.17	.40	17.57	16.70	8.47	36.92	[illegible]
5	925	736	[illegible]	"	94	16.92	.58	17.50	[illegible]	27.10	51.25	[illegible]
6	650	[illegible]	[illegible]	"	103	16.70	.70	[illegible]	12.01	137.04	55.47	8.24
7	450	375	314	Idle	0	4.75	.03	[illegible]	1.90	3.14	2.94	0
8	650	1411	[illegible]	3200	145	27.72	1.00	[illegible]	19.71	85.26	79.69	11.60
9	1000	437	1047	"	106	27.67	.78	28.47	31.06	26.30	67.50	8.49
10	850	307	[illegible]	"	72	27.73	.62	28.35	25.45	18.31	50.21	5.76
11	575	373	440		33	28.01	.42	28.51	15.91	22.37	29.30	2.64
12	665	437	197	"	0	17.38	.29	17.56	12.49	16.50	7.94	0
13	450	293	239	Idle	0	4.82	.03	4.85	1.93	3.19	2.19	0
								TOTALS	177.11	377.58	414.03	50.40

		RUN 1	RUN 2
g/hr C_nH_{2n} = 0.0132 (ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)	BSHC, g/bhp hr	3.88	3.51
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)	BSCO, g/bhp hr	7.49	7.52
g/hr NO = 0.0782 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)	BSNO, g/bhp hr	7.97	8.21

TABLE F-50. CATERPILLAR 1150 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 880/Ford
Source: Brown Express
Odom, Miles: 16,156
Date Tested: 3-22-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.08	29.06	-
Dry Bulb, °F	94	97	100
Wet Bulb, °F	64	63	66

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	350	346	176	Idle	—0—	6.20	.02	6.22	1.93	3.79	2.07	—0—
2	612	412	156	1800	—0—	18.59	.13	18.71	12.09	16.22	6.58	—0—
3	525	359	405	"	24	18.55	.22	18.77	10.41	14.18	17.15	1.92
4	950	255	771	"	63	18.66	.40	19.06	19.12	10.23	33.15	5.04
5	975	268	1179	"	99	18.50	.60	19.10	19.67	10.77	50.80	7.12
6	675	2,511	1281	"	135	18.33	.80	19.13	13.64	101.07	55.29	10.90
7	400	386	282	Idle	—0—	6.20	.02	6.22	2.20	4.23	3.31	—0—
8	500	1248	1179	3000	166.5	28.53	1.13	29.66	15.66	77.59	78.89	13.32
9	950	479	929	"	126	28.50	.90	29.40	29.49	29.63	61.62	10.09
10	925	351	677	"	78	28.50	.65	29.15	29.47	22.02	44.52	6.24
11	650	386	464	"	40.5	28.50	.46	28.96	19.88	23.52	30.31	3.24
12	712	452	239	"	—0—	28.25	.33	28.58	21.49	24.18	15.41	—0—
13	375	359	228	Idle	—0—	6.20	.02	6.22	2.06	3.93	2.68	—0—
								TOTALS	196.11	344.65	401.77	59.56

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	400	359	176	Idle	—0—	6.20	.02	6.22	2.20	3.93	2.07	—0—
2	625	412	166	1800	—0—	18.58	.13	18.71	12.35	16.22	7.01	—0—
3	575	359	405	"	27	18.58	.23	18.81	11.42	14.21	17.19	2.16
4	950	255	758	"	63	18.50	.40	18.90	18.96	10.14	32.32	5.04
5	962	242	1163	"	96	18.41	.58	18.99	19.29	9.67	49.82	7.68
6	662	2,210	1281	"	135	18.33	.80	19.13	13.37	92.98	55.28	10.90
7	400	359	271	Idle	—0—	6.20	.03	6.23	2.20	3.94	3.19	—0—
8	475	1366	1177	3000	165	28.53	1.12	29.65	14.87	85.22	78.86	13.20
9	962	452	1004	"	124.5	28.50	.88	29.38	29.85	27.94	66.55	9.96
10	950	346	833	"	76.5	28.50	.64	29.14	29.23	21.21	54.76	6.12
11	625	357	464	"	37.5	28.50	.45	28.95	19.11	21.87	30.30	3.00
12	700	425	239	"	—0—	28.50	.31	28.81	21.30	25.76	15.53	—0—
13	362	346	228	Idle	—0—	6.20	.02	6.22	1.99	3.79	2.68	—0—
								TOTALS	196.14	336.88	415.56	57.96

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	3.34	3.38
BSCO, g/bhp hr	5.88	5.81
BSNO, g/bhp hr	6.86	7.16

TABLE F-51. CATERPILLAR 1150 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 881/Ford
Source: Brown Express
Odom, Miles: 11,781
Date Tested: 3-23-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.05	29.05	29.05
Dry Bulb, °F	81	89	86
Wet Bulb, °F	65	67	66

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	375	320	186	Idle	—0—	6.20	.03	6.23	2.07	3.51	2.19	—0—
2	612	412	156	1800	—0—	18.58	.13	18.71	12.09	16.22	6.58	—0—
3	512	359	393	"	30	18.55	.24	18.79	10.16	14.19	16.66	2.40
4	850	212	841	"	72	18.50	.45	18.95	17.01	8.45	35.95	5.76
5	900	212	1179	"	100.5	18.41	.60	19.01	18.07	8.48	50.56	8.04
6	562	2974	1298	"	138	18.33	.83	19.16	11.37	119.89	56.11	11.04
7	388	294	249	Idle	—0—	6.20	.03	6.23	2.14	3.23	2.93	—0—
8	400	1920	1264	3000	174	28.53	1.18	29.71	12.55	120.02	84.72	13.92
9	900	412	1092	"	132	28.50	.92	29.42	27.96	25.50	71.81	10.56
10	962	294	785	"	87	28.58	.68	29.26	29.72	18.10	51.82	6.96
11	575	346	500	"	40.5	28.50	.47	28.97	17.59	21.09	32.68	3.24
12	725	425	239	"	—0—	28.50	.30	28.80	22.05	25.75	15.53	—0—
13	375	307	186	Idle	—0—	6.20	.03	6.20	2.06	3.35	2.18	—0—
								TOTALS	184.84	387.78	429.92	61.92

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	388	307	186	Idle	—0—	6.20	.03	6.23	2.14	3.37	2.19	—0—
2	638	412	166	1800	—0—	18.58	.13	18.71	12.61	16.22	7.01	—0—
3	550	346	416	"	30	18.55	.24	18.79	10.91	13.68	17.63	2.40
4	900	203	856	"	70.5	18.41	.45	18.86	17.92	8.06	36.42	5.64
5	1000	242	1264	"	102	18.41	.61	19.01	20.07	9.68	54.21	8.16
6	575	3142	1298	"	136.5	18.33	.81	19.14	11.62	126.53	56.05	10.92
7	375	294	249	Idle	—0—	6.20	.03	6.23	2.07	3.23	2.93	—0—
8	375	2080	1264	3000	174	28.25	1.17	29.42	11.69	128.75	83.89	13.92
9	888	386	1098	"	126	28.50	.89	29.39	27.56	23.87	72.80	10.08
10	950	281	813	"	85.5	28.50	.67	29.17	29.26	17.25	53.50	6.84
11	550	333	512	"	40.5	28.50	.46	28.96	16.82	20.29	33.45	3.24
12	725	412	239	"	—0—	28.50	.30	28.80	22.05	24.97	15.53	—0—
13	362	307	197	Idle	—0—	6.20	.02	6.22	1.99	3.36	2.32	—0—
								TOTALS	186.71	399.26	437.93	61.20

g/hr C_nH_{2n} = 0.0132 (ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	2.98	3.05
BSCO, g/bhp hr	6.26	6.52
BSNO, g/bhp hr	6.93	7.15

TABLE F-52. CATERPILLAR 1150 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 883/Ford
Source: Brown Express
Odom, Miles: 11,479
Date Tested: 4-22-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	28.81	28.77	28.77
Dry Bulb, °F	84	90	92
Wet Bulb, °F	72	75	75

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	563	399	145	500	0	6.20	.03	6.23	3.16	4.38	1.71	0
2	888	532	125	1800	0	18.58	.13	18.71	[illegible]	20.94	[illegible]	0
3	738	412	[illegible]	"	37	18.32	.27	18.59	14.49	16.11	[illegible]	[illegible]
4	1200	242	744	"	69	18.37	.43	18.80	[illegible]	[illegible]	[illegible]	[illegible]
5	1275	268	1196	"	102	18.29	.62	18.91	25.46	10.66	51.02	8.16
6	913	2935	1298	"	136	18.27	.82	19.09	15.41	[illegible]	[illegible]	10.88
7	525	452	207	500	0	6.20	.03	6.23	2.89	4.96	3.44	0
8	600	2494	1130	3000	172	27.56	1.17	28.73	18.20	150.96	[illegible]	13.76
9	1263	346	974	"	122	27.63	.87	28.50	[illegible]	[illegible]	62.62	9.76
10	1288	333	664	"	76	27.73	.63	28.36	38.57	[illegible]	[illegible]	6.08
11	735	439	416	"	38	27.84	.45	28.29	22.05	26.13	26.55	3.04
12	1000	586	166	"	0	27.83	.30	28.13	[illegible]	34.69	10.53	0
13	525	435	166	500	0	6.20	.13	6.23	2.89	4.67	1.75	0
								TOTALS	235.14	[illegible]	[illegible]	60.16

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	538	425	145	500	0	6.20	.03	6.23	2.96	4.67	1.71	0
2	850	519	115	1800	0	18.58	.13	18.71	16.79	20.43	4.85	0
3	738	425	382	"	34	18.41	.27	18.68	14.56	16.70	16.10	2.72
4	1213	242	771	"	69	18.43	.43	18.86	24.16	9.60	32.80	5.52
5	1275	255	1213	"	101	18.38	.60	18.98	25.55	10.18	51.74	8.08
6	938	3030	1316	"	136	18.23	.83	19.06	18.88	121.51	56.57	10.88
7	525	452	218	500	0	6.20	.03	6.23	2.89	4.96	3.57	0
8	538	2277	1147	3000	174	27.55	1.18	28.73	16.32	137.64	74.34	13.92
9	1250	373	974	"	122	27.63	.87	28.50	37.62	22.37	62.62	9.76
10	1225	346	664	"	76	27.73	.63	28.36	36.69	20.65	42.48	6.08
11	738	425	428	"	38	27.74	.45	28.29	22.05	25.30	27.32	3.04
12	950	532	176	"	0	27.83	.30	28.13	[illegible]	31.49	11.17	0
13	525	425	176	500	0	6.20	.03	6.23	2.89	4.67	2.07	0
								TOTALS	249.58	430.17	386.56	60.00

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)

g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)

g/hr NO = 0.0282(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	4.24	4.16
BSCO, g/bhp hr	7.33	7.17
BSNO, g/bhp hr	6.35	6.44

TABLE F-53. CATERPILLAR 1150 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 884/Ford
Source: Brown Express
Odom, Miles: 21,645
Date Tested: 3-25-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.06	29.03	-
Dry Bulb, °F	85	89	-
Wet Bulb, °F	68	69	-

RUN 1

MODE	C_nH_n, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	388	320	145	Idle	—	6.09	.03	6.12	2.10	3.45	1.68	—
2	650	386	135	1800	—	18.28	.13	18.41	12.64	14.95	5.61	—
3	625	333	382	"	33	18.05	.26	18.31	11.91	12.83	15.78	2.64
4	950	178	799	"	69	17.78	.43	18.21	17.84	6.82	32.82	5.52
5	975	359	1230	"	109	17.45	.66	18.11	18.65	13.68	50.25	8.72
6	450	3603	1281	"	178	16.97	.83	17.80	8.46	134.94	51.44	11.04
7	475	346	218	Idle	—	5.93	.03	5.96	2.50	3.63	2.45	—
8	500	2683	1130	3000	180	27.34	1.22	28.56	15.08	161.22	72.81	14.40
9	925	709	1004	"	140	27.33	.97	28.30	27.64	42.22	64.10	11.20
10	875	307	730	"	87	27.01	.68	27.69	25.59	17.89	45.60	6.96
11	600	307	452	"	44	26.79	.48	27.27	17.28	11.16	27.81	3.52
12	788	439	197	"	—	26.96	.32	27.28	22.70	20.97	12.12	—
13	450	307	166	Idle	—	5.93	.03	5.96	2.37	3.22	1.87	—
								TOTALS	184.76	446.98	384.34	64.00

RUN 2

MODE	C_nH_n, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1					—							—
2					—							—
3												
4												
5												
6												
7					—							—
8												
9												
10												
11												
12					—							—
13					—							—
								TOTALS				

		RUN 1	RUN 2
g/hr C_nH_{2n} = 0.0132 (ppm C_nH_n)(EXH. FLOW, lb/min)(Weight Factor)	BSHC, g/bhp hr	2.89	—
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)	BSCO, g/bhp hr	6.98	—
g/hr NO = 0.0282 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)	BSNO, g/bhp hr	6.01	—

TABLE F-54. CATERPILLAR 1150 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 885/Ford
Source: Brown Express
Odom, Miles: 12,752
Date Tested: 3-24-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.09	29.07	29.06
Dry Bulb, °F	75	83	96
Wet Bulb, °F	63	71	73

RUN 1

MODE	C,H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	450	386	135	Idle	———	6.20	.03	6.23	2.48	4.24	1.59	———
2	725	492	115	1800	———	18.67	.14	18.81	14.40	19.47	4.88	———
3	650	399	326	"	33	18.42	.26	18.68	12.82	15.68	13.74	2.64
4	962	255	677	"	66	18.22	.42	18.64	18.94	10.00	28.47	5.28
5	1000	242	1066	"	99	18.00	.60	18.60	19.64	9.47	44.73	7.92
6	750	2718	1230	"	136	17.66	.82	18.48	14.64	105.68	51.28	10.88
7	400	373	218	Idle	———	6.13	.03	6.16	2.18	4.05	2.54	———
8	462	2046	1098	3000	175	28.24	1.18	29.42	14.35	126.77	72.88	14.00
9	1075	373	885	"	122	28.01	.87	28.88	32.78	22.66	57.66	9.76
10	912	346	599	"	79	27.76	.64	28.40	27.35	20.67	38.38	6.32
11	625	439	348	"	39	27.73	.45	28.18	16.60	26.03	22.12	3.12
12	838	519	176	"	———	27.80	.33	28.13	24.89	30.72	11.17	———
13	400	373	176	Idle	———	6.10	.03	6.13	2.17	4.03	2.04	———
								TOTALS	205.24	399.47	351.48	59.92

RUN 2

MODE	C.H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	462	386	166	Idle	———	6.20	.03	6.23	2.55	4.24	1.95	———
2	675	425	135	1800	———	18.67	.13	18.80	13.40	16.51	5.73	———
3	625	412	348	"	32	18.08	.25	18.33	12.58	15.89	14.39	2.56
4	912	255	703	"	65	17.89	.41	18.30	17.62	9.45	29.02	5.20
5	975	242	1098	"	98	17.61	.59	18.20	18.74	9.27	45.08	7.84
6	750	2563	1264	"	135	17.34	.81	18.15	14.37	97.87	51.76	10.80
7	425	399	239	Idle	———	6.00	.03	6.03	2.27	4.24	2.72	———
8	450	2211	1114	3000	175	27.74	1.18	28.92	13.74	134.53	72.68	14.00
9	1038	386	929	"	122	27.42	.87	28.29	31.01	22.98	64.99	9.76
10	900	346	638	"	76	27.28	.63	27.91	26.53	20.32	40.17	6.08
11	625	399	393	"	36	27.06	.44	27.50	18.15	23.09	24.38	2.88
12	812	465	197	"	———	27.12	.31	27.43	23.52	26.84	12.19	———
13	388	359	197	Idle	———	5.93	.03	5.96	2.05	3.77	2.22	———
								TOTALS	196.53	389.30	367.28	59.12

g/hr C_nH_{2n} = 0.0132 (ppm C,H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	3.43	3.32
BSCO, g/bhp hr	6.67	6.58
BSNO, g/bhp hr	5.87	6.21

TABLE F-55. GM DH 478 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 118/GMC
Source: Coca Cola
Odom, Miles: 8,578
Date Tested: 3-13-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.08	29.08	29.05
Dry Bulb, °F	81	81	84
Wet Bulb, °F	78	75	77

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	500	255	135	Idle	—	5.70	.03	5.73	2.53	2.57	1.46	—
2	900	399	66	2000	—	18.30	.13	18.43	17.52	15.47	2.74	—
3	800	425	156	"	32	18.15	.30	18.45	15.59	16.50	6.49	2.56
4	700	399	260	"	61	17.90	.38	18.28	18.51	15.35	10.72	4.88
5	750	281	475	"	88	17.30	.53	17.83	14.12	10.54	19.11	7.04
6	350	1577	744	"	116	16.90	.72	17.62	6.51	58.46	29.57	9.28
7	500	216	207	Idle	—	5.60	.03	5.63	2.49	2.14	2.20	—
8	538	2343	703	2800	141	24.20	.92	25.12	14.27	123.83	39.84	11.28
9	512	559	638	"	112	24.65	.73	25.38	13.72	29.85	36.53	8.96
10	700	373	314	"	70	24.95	.52	25.47	18.83	19.99	18.04	5.60
11	788	425	197	"	51	24.95	.43	25.38	21.12	22.69	11.28	4.08
12	925	465	106	"	—	24.75	.32	25.07	24.49	24.53	6.00	—
13	488	216	166	"	—	5.60	.03	5.63	2.42	2.14	1.77	—
								TOTALS	172.12	344.06	185.75	53.68

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	512	242	135	Idle	—	5.70	.03	5.73	2.59	2.44	1.46	—
2	900	386	66	2000	—	18.30	.13	18.43	17.52	14.97	2.74	—
3	825	412	156	"	32	17.95	.30	18.25	15.90	15.82	6.42	2.56
4	738	386	260	"	53	17.75	.35	18.10	14.11	14.70	10.62	4.24
5	750	255	487	"	76	17.15	.47	17.62	13.96	9.45	19.36	6.08
6	362	1577	758	"	114	16.75	.70	17.45	6.67	57.90	29.84	9.12
7	500	190	197	Idle	—	5.55	.03	5.58	2.47	1.87	2.08	—
8	500	2343	703	2800	136	24.15	.88	25.03	13.22	123.39	39.70	10.88
9	512	572	625	"	108	25.60	.72	26.32	14.23	31.68	37.11	8.64
10	700	346	314	"	66	25.95	.50	26.45	19.55	19.26	18.74	5.28
11	775	412	197	"	48	24.95	.42	25.37	20.72	21.99	11.28	3.84
12	938	452	106	"	—	24.60	.30	24.90	24.66	23.68	5.95	—
13	488	203	156	Idle	—	5.50	.03	5.53	2.39	1.98	1.63	—
								TOTALS	167.99	339.13	186.93	50.64

g/hr C_nH_{2n} = 0.0132 (ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	3.21	3.32
BSCO, g/bhp hr	6.41	6.70
BSNO, g/bhp hr	3.46	3.69

TABLE F-56. GM DH 478 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 133/GMC
Source: Coca Cola
Odom, Miles: 10,602
Date Tested: 3-6-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.06	29.10	29.11
Dry Bulb, °F	65	67	81
Wet Bulb, °F	50	50	57

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	388	268	147	Idle	—	5.70	.03	5.73	1.97	2.71	2.13	—
2	600	386	96	2000	—	18.30	.15	18.45	11.69	14.98	4.00	—
3	500	399	249	"	28	18.15	.30	18.45	9.74	15.49	10.36	2.24
4	525	281	500	"	60	17.90	.38	18.28	10.13	10.81	20.62	4.80
5	438	333	771	"	91	17.60	.55	18.15	8.39	12.72	31.57	7.28
6	425	695	914	"	103	17.20	.62	17.82	8.00	26.06	36.74	8.24
7	400	203	282	Idle	—	5.60	.03	5.63	1.99	2.01	3.00	—
8	588	1920	929	2800	149	24.85	.98	25.83	16.04	104.34	54.14	11.92
9	450	268	813	"	105	25.15	.70	25.85	12.28	14.58	47.41	8.40
10	275	165	574	"	76	25.20	.55	25.75	7.48	8.94	33.34	6.08
11	525	346	282	"	35	25.20	.37	25.57	14.18	18.61	16.27	2.80
12	638	359	156	"	—	25.00	.28	25.28	17.03	19.09	8.90	—
13	375	216	239	Idle	—	5.65	.03	5.68	1.88	2.16	2.56	—
								TOTALS	120.80	252.50	271.04	51.76

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	350	255	197	Idle	—	5.70	.03	5.73	1.77	2.57	2.13	—
2	562	373	96	2000	—	18.30	.15	18.45	10.95	14.48	4.00	—
3	525	386	207	"	28	18.15	.30	18.45	10.23	14.98	8.62	2.24
4	550	281	464	"	53	17.90	.35	18.25	10.60	10.79	19.10	4.24
5	475	320	744	"	89	17.60	.53	18.13	9.09	12.21	30.43	7.12
6	400	764	914	"	112	17.15	.68	17.83	7.53	28.66	36.77	8.96
7	388	203	271	Idle	—	5.65	.03	5.68	1.95	2.03	2.91	—
8	538	2048	944	2800	152	24.85	1.02	25.87	14.70	111.47	55.09	12.16
9	412	268	827	"	112	25.15	.73	25.88	11.26	14.59	48.28	8.96
10	212	152	599	"	73	25.20	.53	25.73	5.76	8.23	34.77	5.84
11	450	333	282	"	31	25.15	.35	25.50	12.12	17.87	16.22	2.48
12	612	359	156	"	—	25.00	.27	25.27	16.33	19.09	8.89	—
13	375	203	228	Idle	—	5.65	.03	5.68	1.88	2.03	2.45	—
								TOTALS	104.17	259.00	269.66	52.00

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	2.33	2.00
BSCO, g/bhp hr	4.88	4.98
BSNO, g/bhp hr	5.24	5.19

TABLE F-57. GM DH 478 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 137/GMC
Source: Coca Cola
Odom, Miles: 2,844
Date Tested: 3-26-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.25	29.25	29.27
Dry Bulb, °F	78	74	71
Wet Bulb, °F	63	63	62

RUN 1

MODE	C,H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	725	320	218	Idle	———	5.70	.03	5.73	3.67	3.23	2.36	———
2	900	452	106	2000	———	18.30	.15	18.45	17.53	17.55	4.41	———
3	825	452	249	"	28	18.15	.23	18.38	16.01	17.48	10.32	2.24
4	662	242	599	"	55	17.90	.36	18.26	12.77	9.30	24.68	4.40
5	762	281	856	"	79	17.62	.48	18.10	14.56	10.70	34.95	6.32
6	625	1456	1147	"	113	17.17	.69	17.86	11.79	54.71	46.22	9.04
7	725	255	282	Idle	———	5.70	.03	5.73	3.67	2.57	3.05	———
8	788	1016	1098	2800	136	24.85	.88	25.73	21.41	55.00	63.74	10.88
9	775	255	944	"	104	25.30	.69	25.99	21.27	13.94	55.35	8.32
10	525	178	651	"	71	25.62	.52	26.14	14.49	9.79	38.39	5.68
11	800	399	282	"	29	25.62	.34	25.96	21.93	21.79	16.52	2.32
12	1038	386	145	"	———	25.50	.26	25.76	28.24	20.92	8.43	———
13	688	255	218	Idle	———	5.70	.03	5.73	3.49	2.57	2.36	———
								TOTALS	190.83	239.55	310.78	49.20

RUN 2

MODE	C,H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	712	294	218	Idle	———	5.70	.03	5.73	3.61	2.97	2.36	———
2	875	452	96	2000	———	18.30	.14	18.44	17.04	17.54	3.99	———
3	800	452	228	"	26	18.15	.22	18.37	15.52	17.47	9.45	2.08
4	662	242	586	"	55	17.90	.36	18.26	12.77	9.30	24.14	4.40
5	688	268	827	"	81	17.62	.49	18.11	13.16	10.21	33.79	6.48
6	612	1292	1098	"	113	17.17	.69	17.86	11.54	48.55	44.24	9.04
7	625	229	282	Idle	———	5.70	.03	5.73	3.17	2.31	3.05	———
8	775	960	1098	2800	138	24.85	.90	25.75	21.07	52.01	63.79	11.04
9	775	242	959	"	107	25.30	.71	26.01	21.29	13.24	56.27	8.56
10	450	152	677	"	70	25.62	.52	26.14	12.42	8.36	39.92	5.60
11	802	399	292	"	31	25.62	.35	25.97	21.94	21.80	17.11	2.48
12	1025	386	145	"	———	25.50	.27	25.77	27.89	20.93	8.43	———
13	675	242	218	Idle	———	5.70	.03	5.73	3.42	2.44	2.36	———
								TOTALS	184.84	227.13	308.90	49.68

g/hr C_nH_{2n} = 0.0132 (ppm C,H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263 (ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782 (ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	3.88	3.72
BSCO, g/bhp hr	4.87	4.57
BSNO, g/bhp hr	6.32	6.22

TABLE F-58. GM DH 478 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 190/GMC
Source: Coca Cola
Odom, Miles: 3,200
Date Tested: 3-5-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.03	29.04	29.04
Dry Bulb, °F	76	72	72
Wet Bulb, °F	67	65	65

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	362	255	156	Idle	———	5.70	,03	5.73	1.83	2.57	1.69	———
2	606	386	76	2000	-------	18.30	.15	18.45	11.69	14.98	3.16	-------
3	525	373	156	"	32	18.15	.25	18.40	10.20	14.44	6.48	2.56
4	488	242	464	"	57	17.90	.37	18.27	9.42	9.30	19.12	4.56
5	450	294	703	"	100	17.45	.60	18.05	8.58	11.17	28.63	8.00
6	285	2113	827	"	125	16.90	.82	17.72	4.21	78.78	33.06	10.00
7	375	216	239	Idle	———	5.65	.03	5.68	1.88	2.16	2.56	———
8	300	2343	799	2800	155	24.40	1.13	25.53	8.09	125.85	46.02	12.40
9	438	359	638	"	123	24.75	.80	25.55	11.82	19.30	36.77	9.84
10	438	294	416	"	80	25.15	.57	25.72	11.90	15.91	24.14	6.40
11	550	425	186	"	39	25.15	.38	25.53	14.83	22.83	10.71	3.12
12	625	412	106	"	———	24.95	.32	25.27	16.68	21.91	6.04	———
13	388	229	166	"	-------	5.65	,03	5.68	1.95	2.29	1.78	-------
								TOTALS	113.08	341.49	220.16	56.88

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	362	294	156	Idle	———	5.70	.03	5.73	1.83	2.97	1.69	———
2	625	412	76	2000	-------	18.30	.15	18.45	12.18	15.99	3.16	-------
3	588	412	166	"	28	18.15	.23	18.38	11.41	15.93	6.88	2.24
4	525	281	475	"	66	17.90	.42	18.32	10.16	10.83	19.63	5.28
5	500	359	690	"	97	17.40	.58	17.98	9.49	13.58	27.99	7.76
6	225	2244	799	"	125	16.95	.82	17.77	4.03	83.90	32.03	10.00
7	400	229	228	Idle	———	5.65	.03	5.68	2.00	2.29	2.45	———
8	312	2410	785	2800	155	24.40	1.15	25.55	8.04	129.55	45.25	12.40
9	462	386	638	"	126	24.75	.82	25.57	12.07	20.77	36.80	10.08
10	462	307	416	"	80	25.20	.57	25.77	12.29	16.65	24.19	6.40
11	562	465	186	"	44	25.20	.40	25.60	14.96	25.05	10.74	3.52
12	650	452	106	"	———	25.00	.32	25.32	17.16	24.08	6.05	———
13	388	255	166	Idle	———	5.70	.03	5.73	1.96	2.57	1.80	———
								TOTALS	117.58	364.16	218.66	57.68

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	1.99	2.04
BSCO, g/bhp hr	6.00	6.31
BSNO, g/bhp hr	3.87	3.79

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TABLE F-59. IHC DV 550B 13 MODE GASEOUS EMISSIONS SUMMARY

Vehicle No/Make: 631/IHC
Source: City Water Board
Odom, Miles: 17,655
Date Tested: 6-4-71

Inlet Conditions	Before	Between	After
Bar, in Hg Corr	29.28	29.30	29.30
Dry Bulb, °F	85	86	84
Wet Bulb, °F	73	74	73

RUN 1

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min.	FUEL FLOW, lb/min.	EXHAUST FLOW, lb/min.	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	338	[illegible]	186	Idle	———	6.20	.03	[illegible]	1.86	4.67	2.19	———
2	612	[illegible]	96	2000	———	19.50	.12	19.62	[illegible]	[illegible]	4.35	———
3	1300	[illegible]	239	"	46	19.00	.23	[illegible]	26.40	[illegible]	[illegible]	[illegible]
4	725	819	524	"	0	19.00	.45	19.45	[illegible]	[illegible]	22.99	[illegible]
5	675	452	1163	"	137	[illegible]	.68	19.68	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	3781	1478	"	176	18.50	[illegible]	[illegible]	11.50	[illegible]	64.33	14.08
7	250	373	239	Idle	———	6.20	[illegible]	6.23	1.38	[illegible]	2.81	———
8	362	[illegible]	[illegible]	3000	170	28.00	[illegible]	[illegible]	11.14	[illegible]	81.95	13.60
9	562	381	[illegible]	"	132	28.00	[illegible]	[illegible]	17.15	[illegible]	[illegible]	10.56
10	[illegible]	439	[illegible]	"	70	28.00	[illegible]	[illegible]	30.44	26.49	47.23	7.20
11	[illegible]	[illegible]	[illegible]	"	38	[illegible]	.47	28.47	[illegible]	[illegible]	17.41	3.04
12	1350	[illegible]	[illegible]	"	———	28.00	.31	[illegible]	[illegible]	[illegible]	11.59	———
13	339	[illegible]	[illegible]	Idle	———	6.20	[illegible]	[illegible]	1.86	[illegible]	2.57	———
								TOTALS	[illegible]	[illegible]	[illegible]	[illegible]

RUN 2

MODE	C_1H_x, ppm	CO, ppm	NO, ppm	ENGINE SPEED, rpm	OBSERVED POWER, bhp	AIR FLOW, lb/min	FUEL FLOW, lb/min	EXHAUST FLOW, lb/min	g/hr C_nH_{2n} (weighted)	g/hr CO (weighted)	g/hr NO (weighted)	OBSERVED bhp (weighted)
1	[illegible]	439	166	Idle	———	6.20	.03	6.23	2.48	4.82	1.95	———
2	725	572	76	2000	———	19.50	.10	19.60	15.01	23.59	3.36	———
3	1500	819	[illegible]	"	50	19.00	.25	19.25	30.47	33.17	9.99	4.00
4	1012	961	500	"	93	19.00	.47	19.47	20.91	35.27	21.96	7.44
5	725	465	1114	"	134	19.00	.67	19.67	15.06	19.24	49.43	10.72
6	688	3902	1405	"	176	18.50	.88	19.38	14.07	159.11	61.43	14.08
7	275	386	218	Idle	———	6.20	.03	6.23	1.52	4.24	2.57	———
8	350	947	1247	3000	168	28.00	1.13	29.13	10.77	51.91	81.95	13.44
9	600	373	744	"	126	28.00	.87	28.87	18.29	22.66	61.48	10.08
10	688	425	717	"	100	28.00	.73	28.73	20.87	25.69	46.47	8.00
11	2025	819	271	"	36	28.00	.46	28.46	60.86	49.04	17.40	2.88
12	1275	350	166	"	———	28.00	.28	28.28	38.08	19.04	10.59	———
13	325	386	197	Idle	———	6.20	.03	6.23	1.79	4.24	2.32	———
								TOTALS	250.11	451.96	369.90	70.64

g/hr C_nH_{2n} = 0.0132(ppm C_1H_x)(EXH. FLOW, lb/min)(Weight Factor)
g/hr CO = 0.0263(ppm CO)(EXH. FLOW, lb/min)(Weight Factor)
g/hr NO = 0.0782(ppm NO)(EXH. FLOW, lb/min)(Weight Factor)

	RUN 1	RUN 2
BSHC, g/bhp hr	3.51	3.54
BSCO, g/bhp hr	6.24	6.40
BSNO, g/bhp hr	5.47	5.24
	8.39	8.03
	11.90	11.57